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APPENDIX A

DERIVATION OF EPFD LIMITS FOR PROTECTION OF GSO FSS SYSTEMS

1. Introduction

As discussed in Section III, WP 4A and JTG 4-9-11 are conducting the studies necessary to assess the adequacy of the WRC-97 provisional limits. This document uses the results of those studies to date, in order to derive single entry EPFD masks that meet Recommendation 3.1 of ITU-R Recommendation S.1323.

2. Principles of EPFD limits derivation

2.1 *Use of a continuous EPFD mask*

As agreed by the JTG 4-9-11, this document derives continuous EPFD masks, with EPFD values defined for all time percentages. These masks represent the statistical nature of the NGSO interference better than the discrete WRC-97 provisional limits.

2.2 *Aggregate versus single entry mask*

Recommend 3.1 of Recommendation S.1323 specifies the amount of the unavailability time percentage generated by all NGSO FSS networks, and acceptable for a GSO link, as being 10% of the carrier total unavailability time at the carrier C/N+I performance objective. This 10% allowance is specified in Recommendation S.1323 as being the aggregate allowance created by all existing NGSO FSS networks. The approach taken by WRC-97, however, was to have in Article S22 single entry EPFD limits, because definition of an aggregate mask in the Radio Regulations could lead to a situation where the first entrant, taking all of the acceptable allowance for itself, would preclude other systems access to the frequency bands.

For each reference antenna size, this document refines and tests an aggregate EPFD mask in accordance with the 10% aggregate allowance defined in Recommendation S.1323, and then derives, from the final aggregate mask, a single entry mask.

2.3 Number N of interfering NGSO systems

WP 4A has conducted several studies concerning NGSO - NGSO sharing. The results of these studies demonstrate that even if it is technically feasible to have three NGSO systems operating in the same frequency bands, severe constraints are imposed on the NGSO systems. Having more than three systems in the same bands would probably not be technically feasible. For this reason, the maximum number of NGSO FSS systems (N) has been set to three in the derivations below.

2.4 Application of Procedure D

Once an initial mask has been derived as presented in Document 4-9-11/253, considering a total number of interfering NGSO systems of 3, the final aggregate mask is derived. This is done by a trial and error process, modifying both the EPFD limits values and also the associated time percentage. In this assessment, the software provided at the last JTG meeting has been used.

As specified by Recommendation S.1323, the impact of each carrier was compared with its performance objectives using the following formula:

$$U_{\text{rain only}} - U_{\text{rain} + \text{NGSO}} \leq P_{\text{GSO}} * 10\%$$

Where:

- $U_{\text{rain only}}$: Unavailability of the GSO carrier with rain only
- $U_{\text{rain} + \text{NGSO}}$: Unavailability of the GSO carrier with rain and NGSO interference
- P_{GSO} : GSO carrier performance objective

In some cases, the GSO carrier unavailability calculated with Procedure D exceeded its own performance objectives. In this case, instead of discarding the GSO carrier not compatible with Recommendation S.1323, the actual performance of the GSO carrier was considered the performance objective. The testing formula then becomes:

$$U_{\text{rain only}} - U_{\text{rain} + \text{NGSO}} \leq U_{\text{rain only}} * 10\%$$

3. Derivation of the EPFD masks

3.1 Derivation of EPFD mask for 10 meter antennas

3.1.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 25 carriers for 10 meter diameter antennas. The specified availability for the carriers ranges from 99% to 99.97%.

One of the carriers, #45, was discarded because the elevation of the carrier was 3° , and the rain model used in Procedure D is not applicable for such case. The rain model used in Procedure D, 618-5, states that, below 10° , phenomena other than just gases and rain are to be taken into account (like scintillation). Below 5° for rain and 10° for gases, formulas implementing 618-5 are more complex, and are not implemented in Procedure D. Furthermore, a liaison statement from 3M to 10-11S on correlation between uplink and downlink rain fade states that above 20° elevation, the paths are not correlated, but below 20° the situation is not so clear. For those reasons, treating carrier #45 through Procedure D would not provide realistic results. More detailed analysis taking these considerations into account would be necessary.

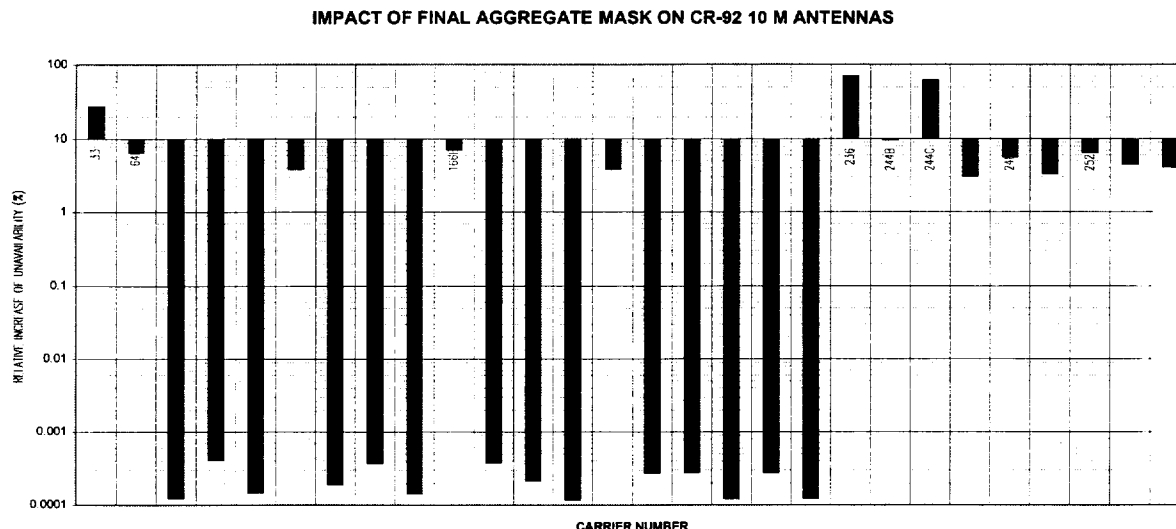
Carrier #6 was submitted by Intelsat at the JTG meeting in Toulouse. However, Intelsat has since claimed that its links were not optimized correctly, and has proposed modified links to take into account its concerns. Carrier #6 was replaced by Intelsat at the Long Beach meeting by carrier #244, and it is this carrier that was used in the derivation.

It should also be noted that CR-92 contains several 10.82 m antennas. These antennas have been considered here, although they should really be assessed for a limit for an 11 m antenna. The results of the application of the 10 m mask is therefore conservative, and provides pessimistic results.

3.1.2 Application of Procedure D to the sample of sensitive carriers

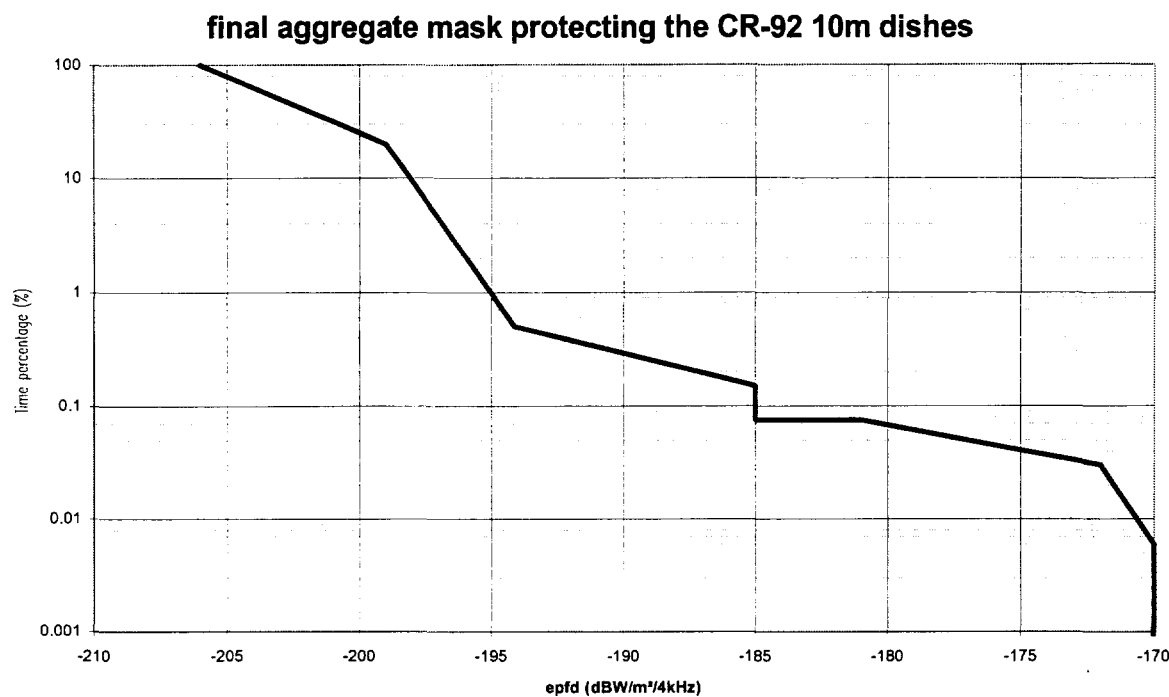
Procedure D has been applied in a trial and error process, adjusting both the EPFD levels and the associated time percentages. For the carriers not meeting their initial performance objective, a 10% increase of the calculated unavailability was taken into account.

The following graph presents the impact on the CR-92 10 m carriers of the derived aggregate mask:



3.1.3 Final aggregate and single entry EPFD mask for 10 m antennas

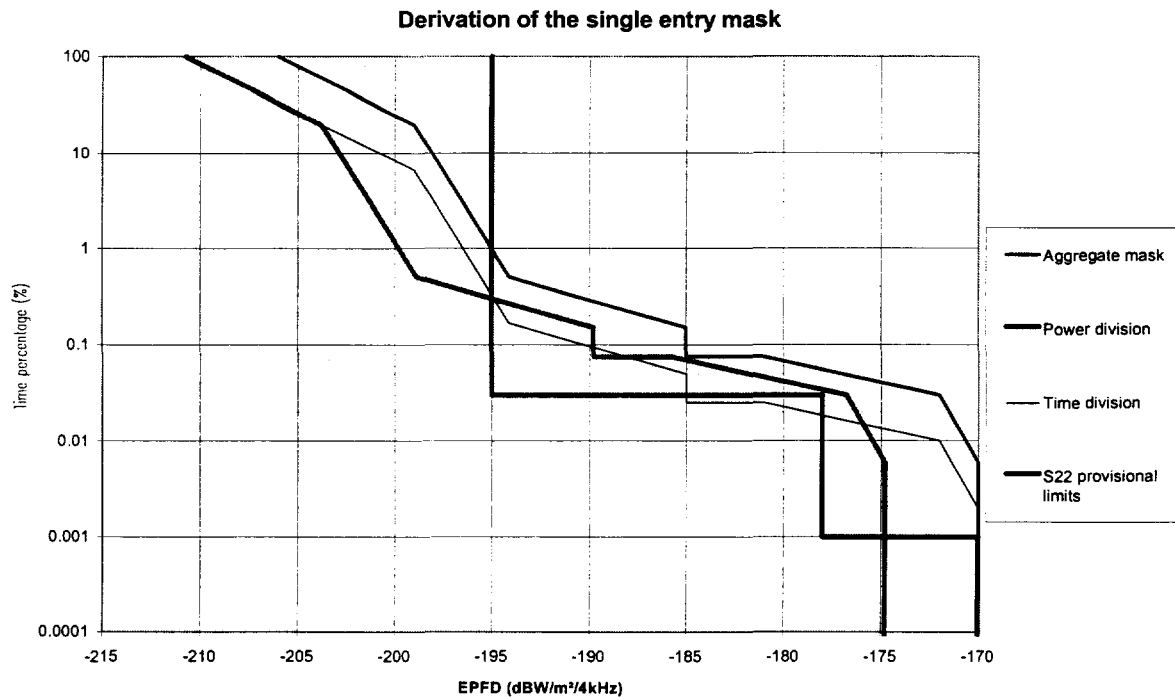
The following graph provides the aggregate EPFD mask:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

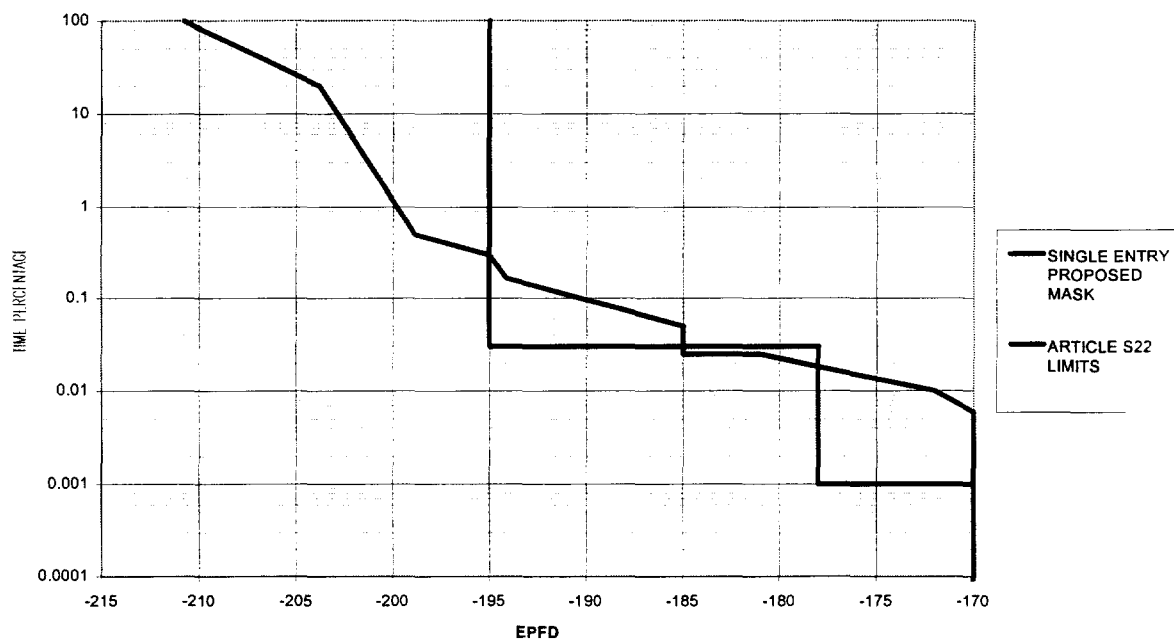
EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-206	100
-199	20
-194.1	0.5
-185	0.15
-185	0.075
-181	0.075
-172	0.03
-170	0.006
-170	0

Applying the methodology described in Document 4-9-11/ 253, the single entry mask is derived from the aggregate mask as shown in the following graph :



As can be seen in the above graph the “power division” and “time division” curves cross, and an envelope of these curves is taken to be conservative. As seen in several contributions to WP 4A and JTG 4-9-11 on the cumulated effects of heterogeneous NGSO FSS systems, the single entry zone (Zone C) starts between 1 and 0.1%. In order to be conservative, in deriving the single entry mask, Zone C was started at 0.01%. Furthermore, a slope between this 0.01% point and the 100% value of the “aggregate curve” was taken to remain conservative. The final single entry mask is presented in the following graph next to the single entry provisional limits in Article S22.

SINGLE ENTRY EPFD MASK PROTECTING CR-92 10M DISHES



The results show that the new proposed mask smooths out the staircase function of the provisional limits.

The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-210.771213	100
-203.771213	20
-198.871213	0.5
-195	0.3
-194.1	0.166666667
-185	0.05
-185	0.025
-181	0.025
-172	0.01
-170	0.006
-170	0

3.2 Derivation of EPFD mask for 3 meter antennas

3.2.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 26 carriers for 3 meter diameter antennas. The specified availabilities for these carriers range from 99% to 99.97%.

Canada submitted 4 carriers for 3 m antennas (#275-# 278). These carriers, clearly optimized with an older and uncompleted version of the Procedure D software, are not usable. The unavailability calculated with rain only at the performance point is 100%. For example, for carrier #275, the associated link budget shows a downlink C/N of 0.71 dB for an overall C/N+I objective of "7.614367708." This could be due to an error in the new CR-92 database that did not copy exactly the parameters given by Canada. For these reasons, these 4 carriers were not taken into account in the derivation of the mask, pending provision of further information.

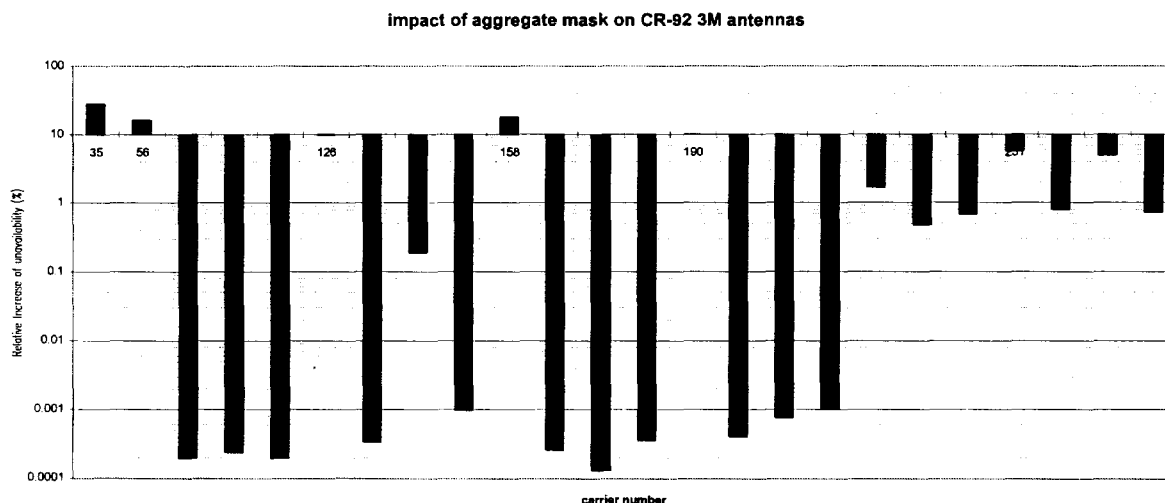
Carrier #9 was submitted by Intelsat at the JTG meeting in Toulouse. Intelsat claimed that its links were not optimized correctly and proposed modified links to take into account its concerns. Carrier #9 was replaced by Intelsat at the Long Beach meeting by carrier #247, which was used in this study.

It should also be noted that the CR-92 contains several 3.31 m antennas. These antennas have been considered here, although they should really be assessed with a limit for a 3.5 m antenna. The results of the application of the 3 m mask will therefore be conservative and provide pessimistic results.

3.2.2 Application of Procedure D to the sample of sensitive carriers

Procedure D was applied in a trial and error process, adjusting both the EPFD levels and the associated time percentages. For the carriers not meeting their initial performance objective, a 10% increase of the calculated unavailability has been taken into account.

The following graph presents the impact on the CR-92 3 m carriers of the aggregate mask :



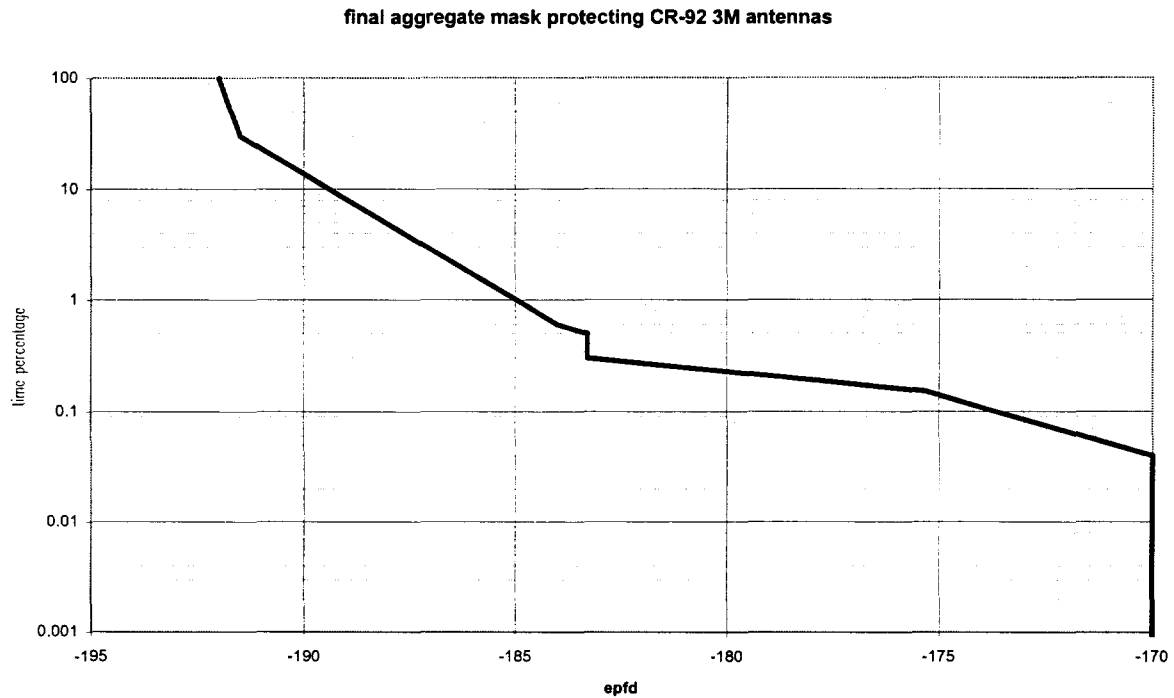
With the proposed mask, all the carriers meet recommends 3.1 of Recommendation S.1323 except three. Of those three carriers, carrier #35 has an increase of 28.4%. The carrier still met its objectives by a significant margin (it has an objective of 99.7% and an availability with the proposed NGSO aggregate mask of 99.88%). The two last carriers have relative increases of unavailability of 16.3% and 18.19%. Both of these two carriers still meet their performance objectives with the proposed aggregate mask.

The percentage of links protected with respect to Rec. 1323 is 85.7%. The percentage of links that still meet their performance objectives with the NGSO aggregate interference is 100%. This means that with the proposed aggregate mask, NO CR-92 carrier will suffer from a degradation of its availability objective.

It should be noted from the graph above that if three carriers are less protected (at least not at the 10% level), they still achieve a very high availability with the NGSO (less than 0.02% of availability reduction). Furthermore, most of the sensitive carriers in CR-92 have relative unavailability increase smaller than 0.01%. The impact on more typical less sensitive links will be even smaller.

3.2.3 Final aggregate and single entry EPFD mask for 3 m antennas

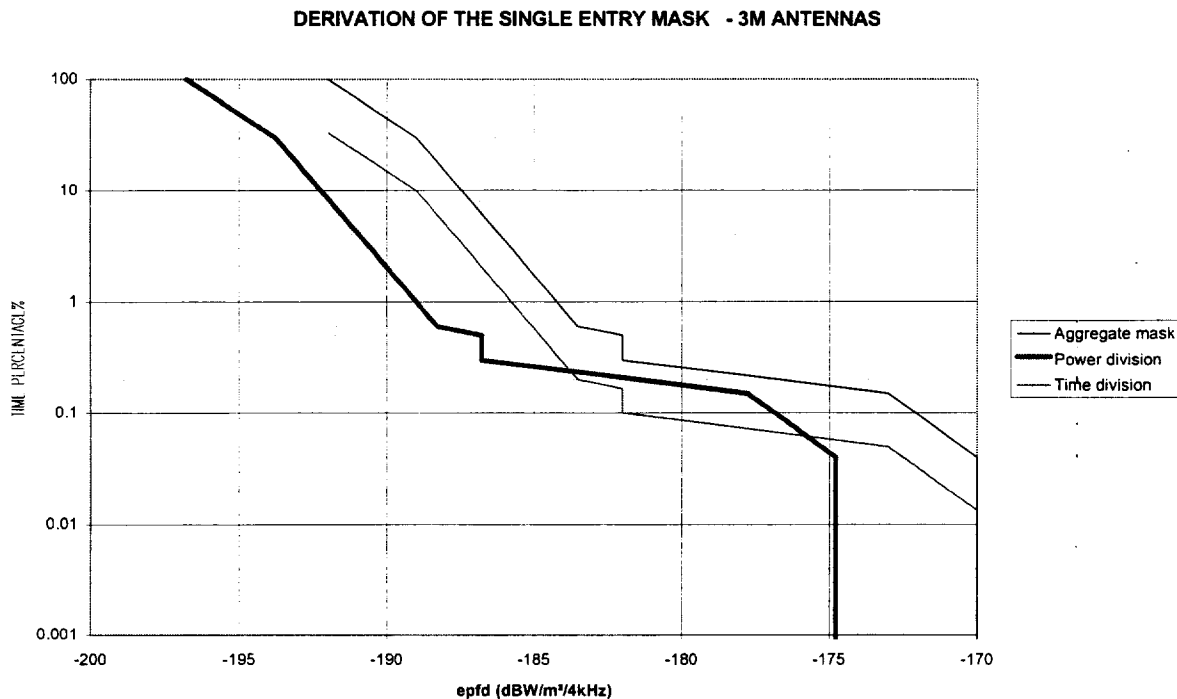
The following graph provides the aggregate EPFD mask:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

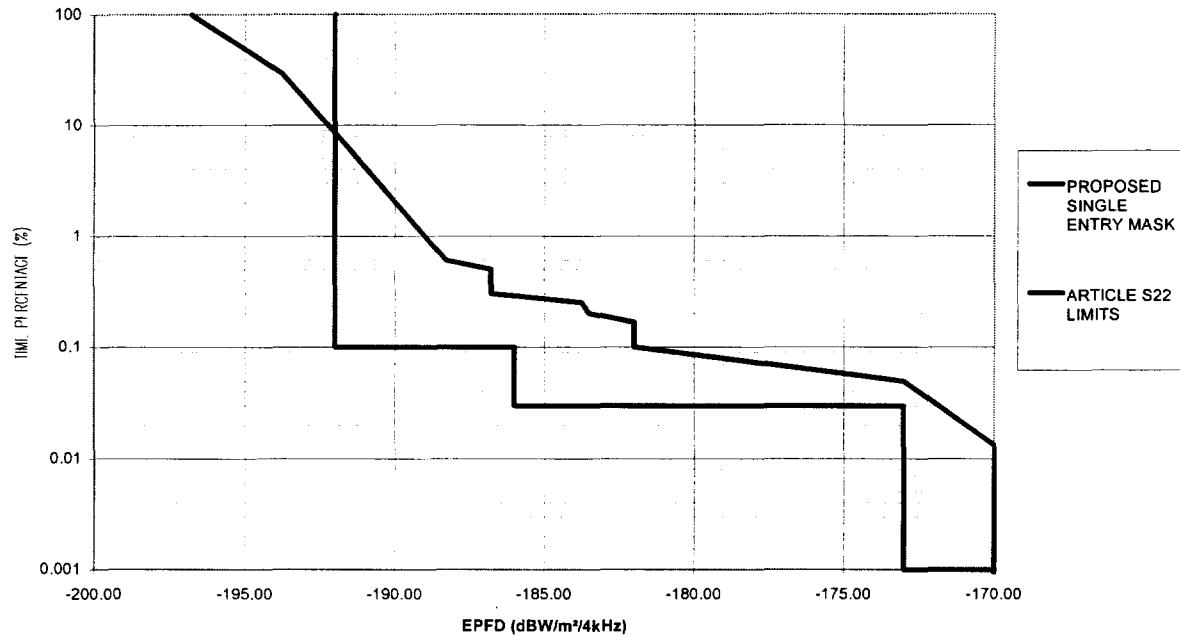
EPFD (dBW/4kHz/m ²)	Percentage of time the level can be exceeded (%)
-192	100
-191.5	30
-184	0.6
-183.3	0.5
-183.3	0.3
-175.3	0.15
-170	0.04
-170	0

Applying the methodology described in Document 4-9-11/253 the single entry mask is derived from the aggregate mask as shown in the following graph :



As can be seen in the above graph the “power division” and “time division” curves cross, and the envelope has been taken in deriving the single entry limits. As seen in several contributions to WP 4A and JTG 4-9-11 on cumulated effects of heterogeneous NGSO FSS systems, the single entry zone (Zone C) starts between 1 and 0.1%. In order to be conservative, Zone C was not taken into account when deriving the 3 m single entry mask. The final single entry mask is presented in the following graph next to the single entry provisional limits in Article S22.

PROPOSED SINGLE ENTRY MASK FOR PROTECTION OF CR-92 3 M ANTENNAS



The results show that the new proposed mask smooths out the staircase interpolation of the provisional limits.

The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-196.77	100
-193.77	30
-188.27	0.6
-186.77	0.5
-186.77	0.3
-183.75	0.25
-183.5	0.2
-182	0.16666667
-182	0.1
-173	0.05
-170	0.013333333
-170	0

3.3 Derivation of EPFD mask for 60 centimeter antennas

3.3.1 Carriers in the CR-92 database

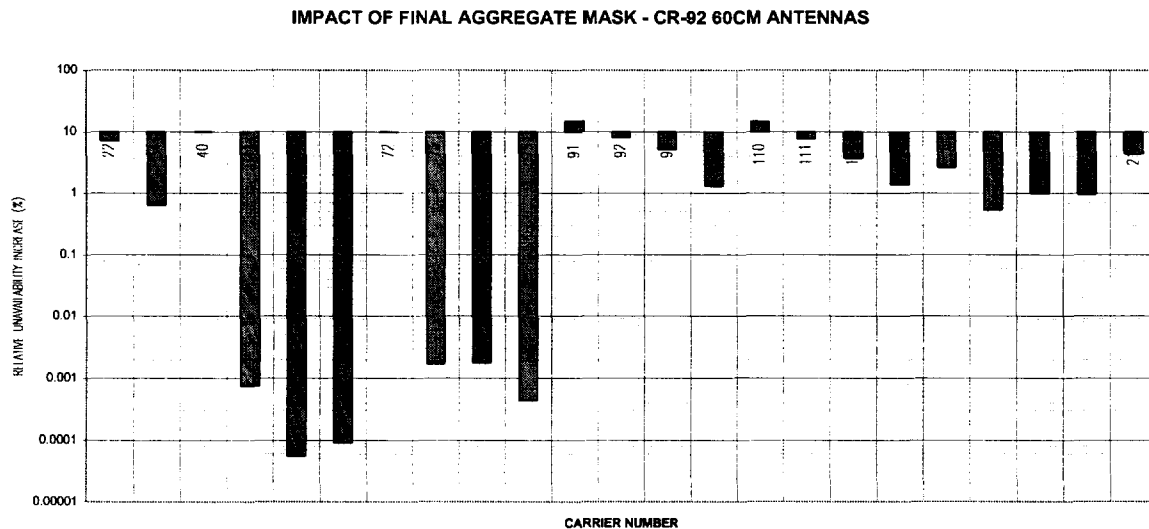
The CR-92 database, as of the close of the JTG Long Beach meeting, contains 23 carriers for 60 cm diameter antennas. The specified availability for these carriers ranges from 99% to 99.97%.

Canada submitted 2 carriers for 60 cm links (#267 and #268). These carriers, clearly optimized with an older and uncompleted version of the Procedure D software, are not usable. The unavailability calculated with rain only at the performance point is 100%. For example, for carrier #267, the associated link budget shows a downlink C/N of -12 dB for an overall C/N+I objective of "3.85337657." This could be due to an error in the new CR-92 database that did not copy exactly the parameters given by Canada. These 2 carriers were not taken into account in the derivation of the mask, pending provision of further information.

3.3.2 Application of Procedure D to the sample of sensitive carriers

Procedure D was applied in a trial and error process, adjusting both the EPFD levels and the associated time percentages. For the carriers not meeting their initial performance objective, a 10% increase of the calculated unavailability has been taken into account.

The following graph presents the impact on the CR-92 60 cm carriers of the aggregate mask :

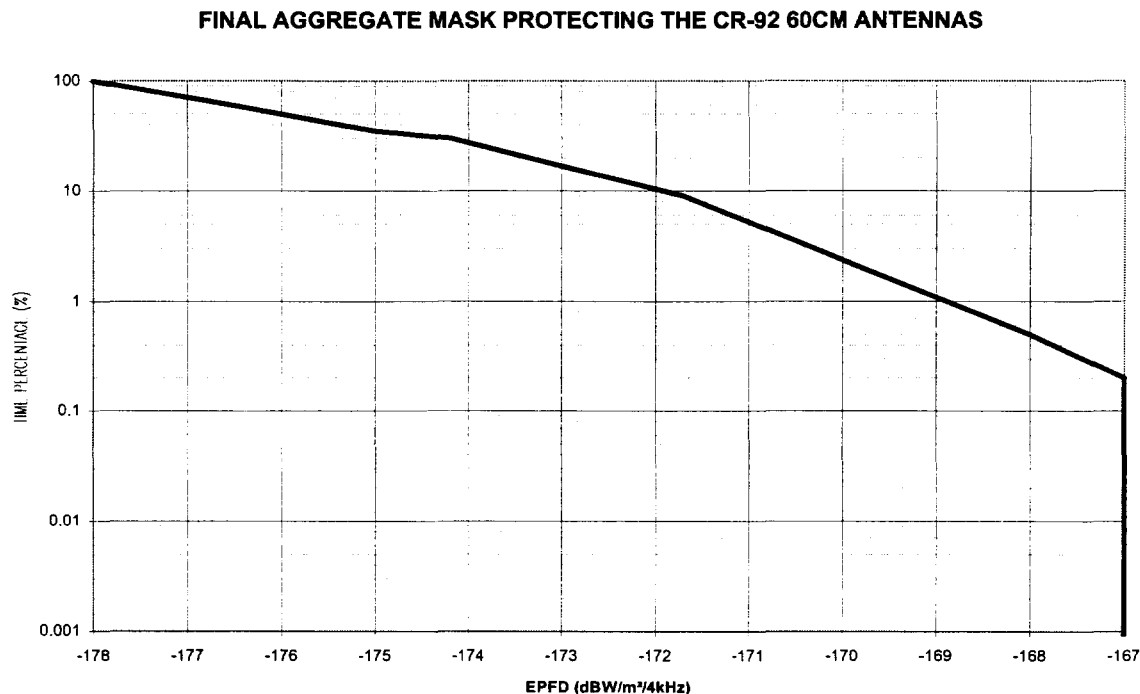


With the proposed mask, all the carriers meet recommends 3.1 of Recommendation S.1323 except two. Carrier #91 has a relative increase in availability of 14.9% and carrier #110 has an increase of 14.7%. However, both of these two carriers still meet their performance objective with the proposed aggregate mask.

The percentage of links protected with respect to Rec. S.1323 is 90.5%. The percentage of links that still meet their performance objectives with the NGSO aggregate interference is 100%. This means that with the proposed aggregate mask, NQ CR-92 carrier will suffer from a degradation of the objective availability.

3.3.3 Final aggregate and single entry EPFD mask for 60 cm antennas

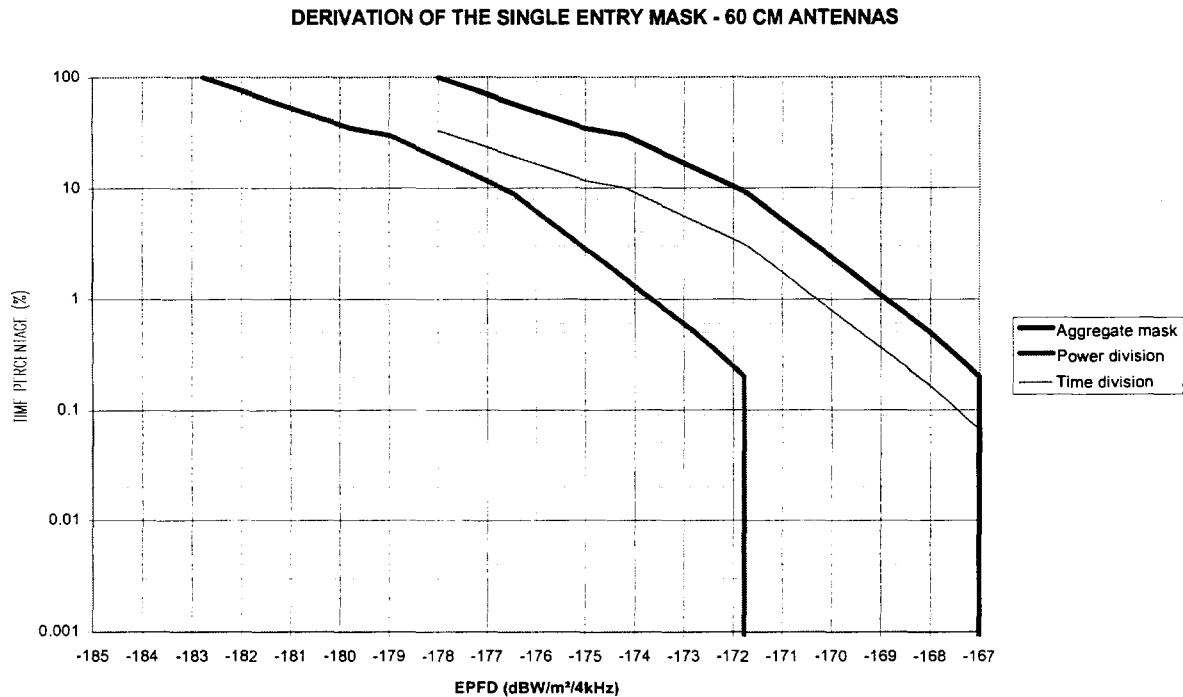
The following graph provides the aggregate EPFD mask:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

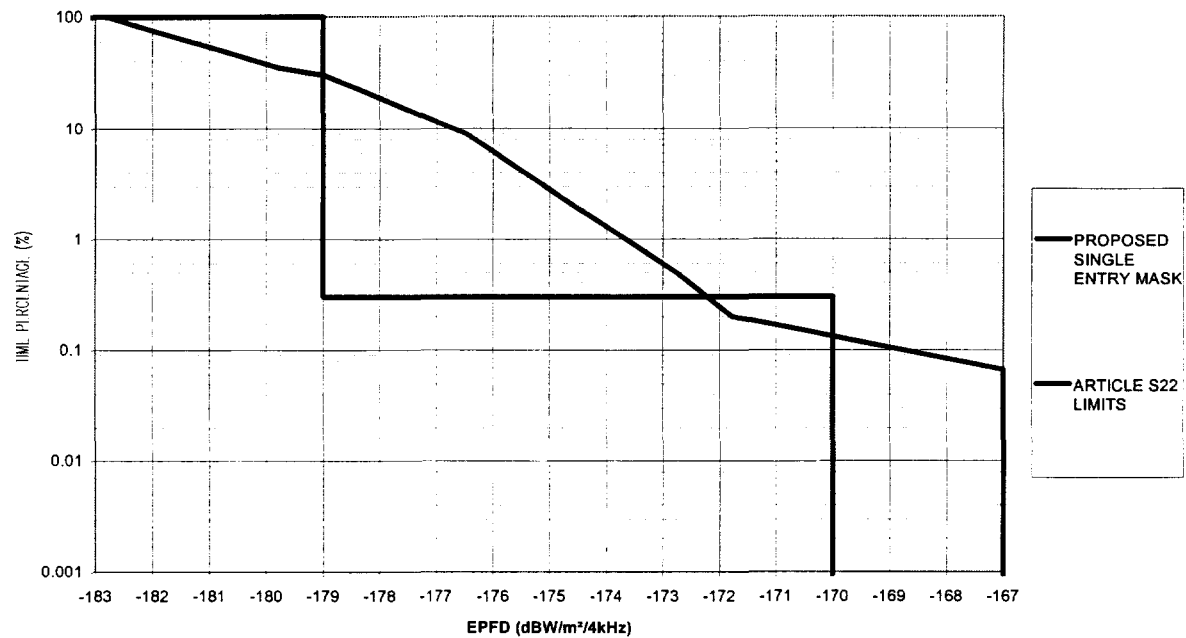
EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-178	100
-175	35
-174.2	30
-171.7	9
-168	0.5
-167	0.2
-167	0

Applying the methodology described in Document JTG 4-9-11/253, the single entry mask is derived from the aggregate mask as shown in the following graph :



As can be seen in the above graph the “power division” and “time division” curves cross, and the envelope has been taken in deriving the single entry mask. As seen in several contributions to WP 4A and JTG 4-9-11 on cumulated effects of heterogeneous NGSO FSS systems, the power addition zone (Zone A) ends for 60 cm antennas between 2 and 0.6%. In order to be conservative, Zone B was started at the 0.2%. Furthermore, it was chosen to tend towards the Zone B curve instead of following it. This means that the limit chosen in Zone B will always be lower then the time addition curve, the two curves matching only for the 100% value. The final single entry mask is presented in the following graph next to the single entry provisional limits in Article S22.

PROPOSED SINGLE ENTRY EPFD MASK FOR CR-92 60CM ANTENNAS



The results show that the new proposed mask smooths out the staircase interpolation of the provisional limits.

The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-182.771213	100
-179.771213	35
-178.971213	30
-176.471213	9
-172.771213	0.5
-171.771213	0.2
-167	0.066666667
-167	0

3.4 Derivation of EPFD mask for 1.2 meter antennas

3.4.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 44 carriers for 1.2 meter diameter antennas. The specified availability for these carriers ranges from 99% to 99.97%.

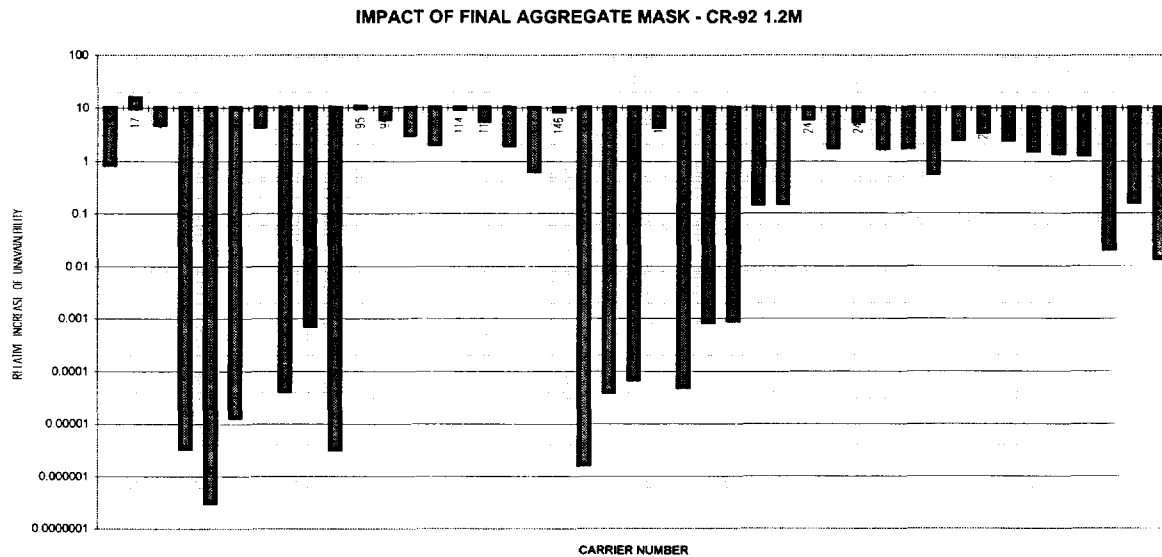
Canada submitted 4 carriers for 1.2 m links (#271, #272, #273, and #282). These carriers, clearly optimized with an older and uncompleted version of the Procedure D software, are not usable. The unavailability calculated with rain only at the performance point is 100%. For example, for carrier #271, the associated link budget shows a downlink C/N -6.11 dB for an overall C/N+I objective of "6.61436771." This could be due to an error in the new CR-92 database that did not copy exactly the parameters given by Canada. Those 4 carriers were not taken into account in the derivation of the mask, pending provision of further information.

Intelsat carriers #202 to #212 are defined for two performance objectives, one for a time percentage of 99%, and one for 99.96 or 99.6%. Neither of the two performance points are ever met by the carriers, which must have been optimized with an older version of the software. Furthermore, the first performance points are not met by a fair amount. The availability calculated is never higher than 91%, instead of 99%. The software has been run with a probability of no rain of 95% on both uplink and downlink. The joint probability of having no rain is 90.25%. This means that those Intelsat carriers have no margin at all to meet the 99% objective. Whatever rain fade is considered, the link fails. Of course, in such a situation, adding NGSO interference immediately brings a high degradation of availability. Because no conclusion could be taken from study of these first performance points, wrongly optimized, they were discarded. The data for the second performance points was used.

3.4.2 Application of Procedure D to the sample of sensitive carriers

Procedure D was applied in a trial and error process, adjusting both the EPFD levels and the associated time percentages. For the carriers not meeting their initial performance objective, a 10% increase of the calculated unavailability has been taken into account.

The following graph presents the impact on the CR-92 1.2 m carriers of the aggregate mask :

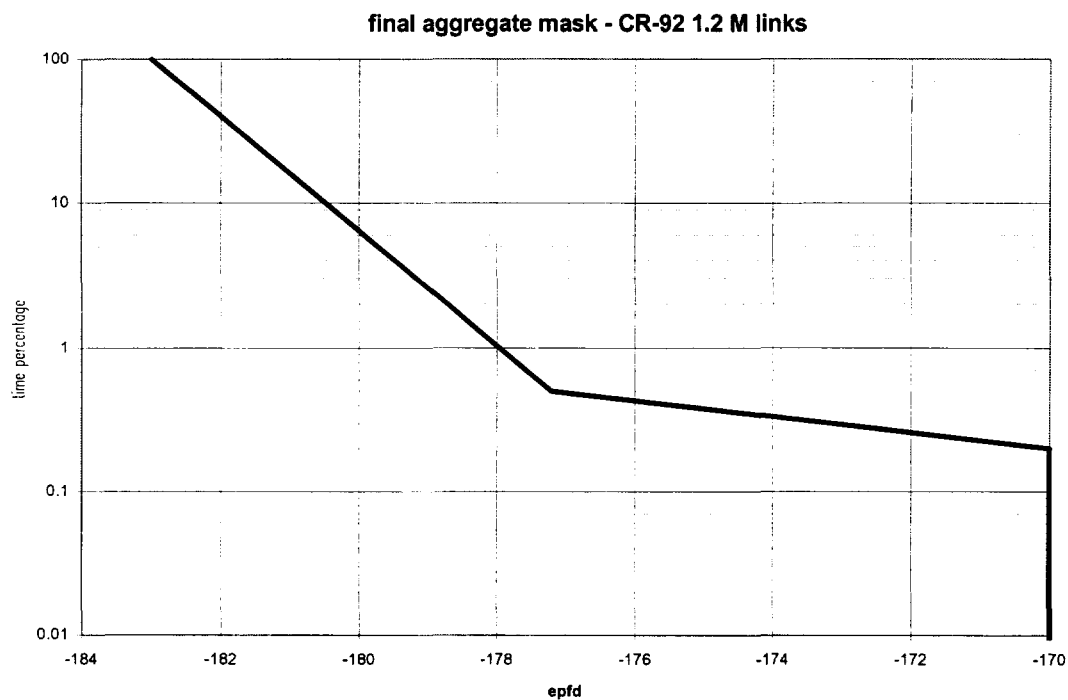


With the proposed mask, all the carriers meet recommends 3.1 of Recommendation S.1323 except two. Carrier #95 has a relative increase in availability of 10.64%, but still meets its objectives. Carrier #17 has an increase of 15.44%. However, this carrier does not meet its performance objective of 99.94% even without NGSOs. Its availability without NGSOs is 99.929%, and with the aggregate mask it is 99.918%, a decrease of only 0.011%.

The percentage of links protected with respect to Rec. S.1323 is 94.87%. The percentage of links that meet their performance objectives without NGSOs and still meet their performance objectives with the NGSO aggregate interference is 100%. This means that with the proposed aggregate mask, NO CR-92 carrier will suffer from a degradation of the objective availability due to the NGSO.

3.4.3 Final aggregate and single entry EPFD mask for 1.2 m antennas

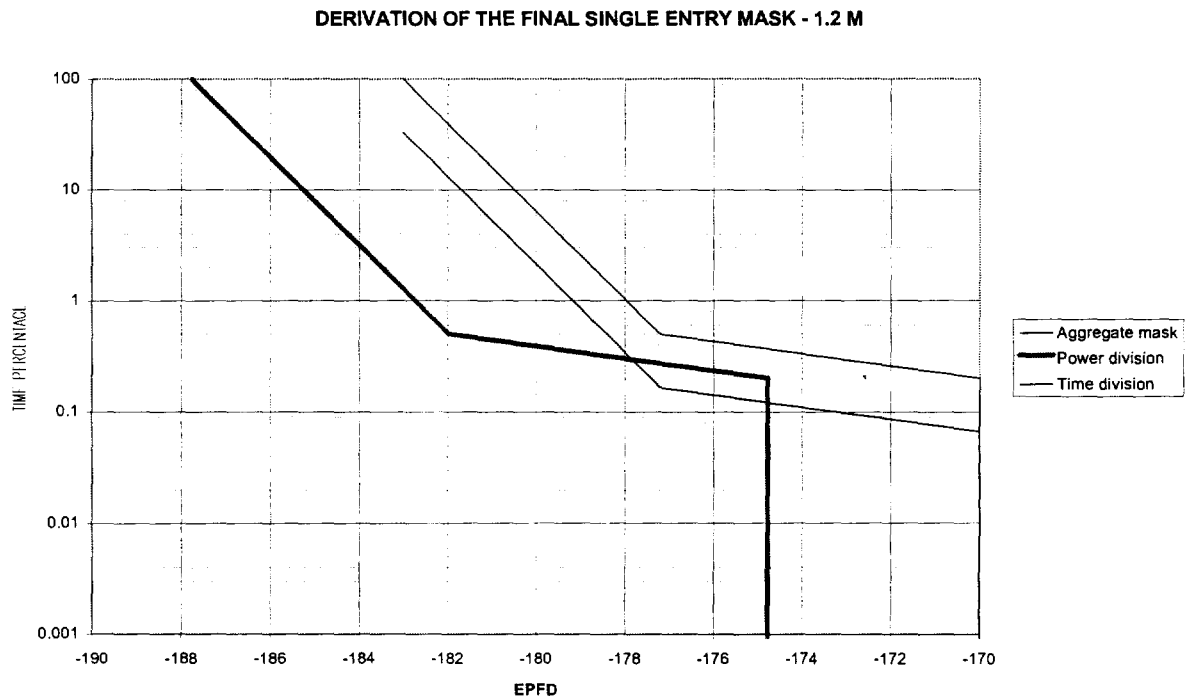
The following graph provides the aggregate EPFD mask verifying:



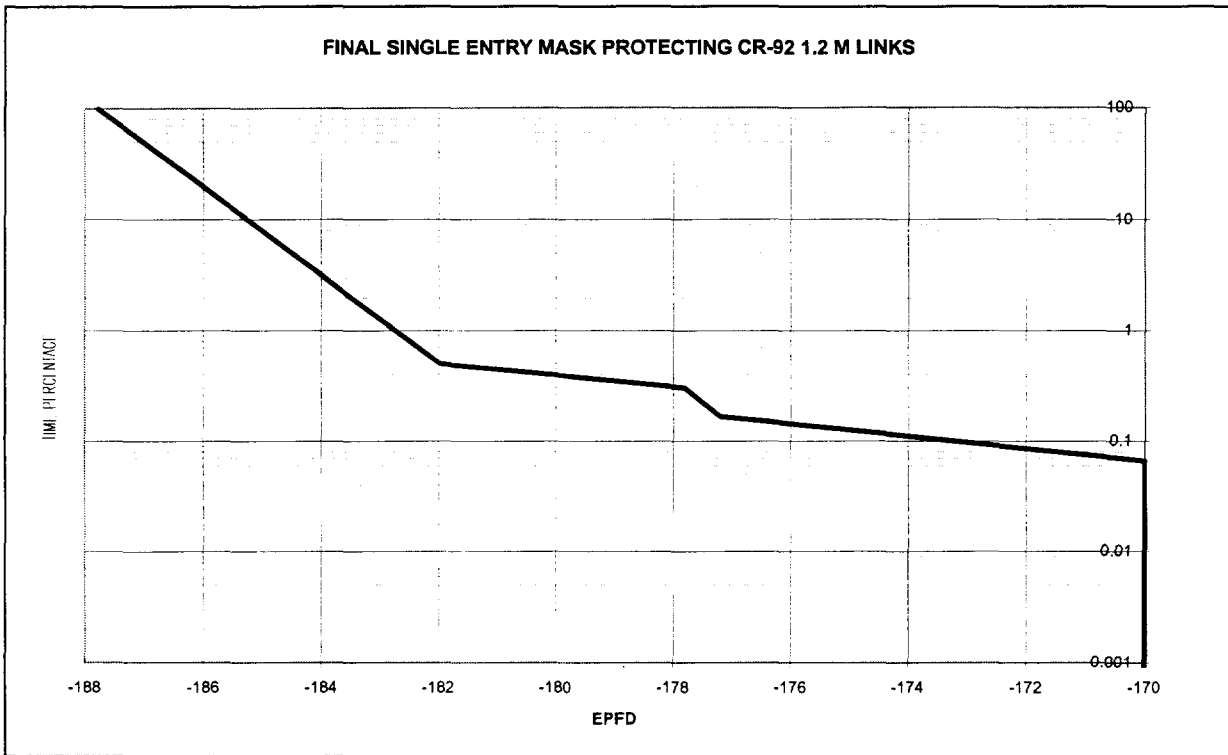
The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-183	100
-177.2	0.5
-170	0.2
-170	0.05
-170	0

Applying the methodology described in Document JTG 4-9-11/253, the single entry mask is derived from the aggregate mask as shown in the following graph :



As can be seen in the above graph the “power division” and “time division” curves cross, and the envelope is taken to derive the single entry mask. Zone C was not used in this case. The final single entry mask is presented in the following graph.



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-187.771213	100
-181.971213	0.5
-177.8	0.3
-177.2	0.16666667
-170	0.06666667
-170	0

3.5 Derivation of EPFD mask for 5 meter antennas

3.5.1 Carriers in the CR-92 database

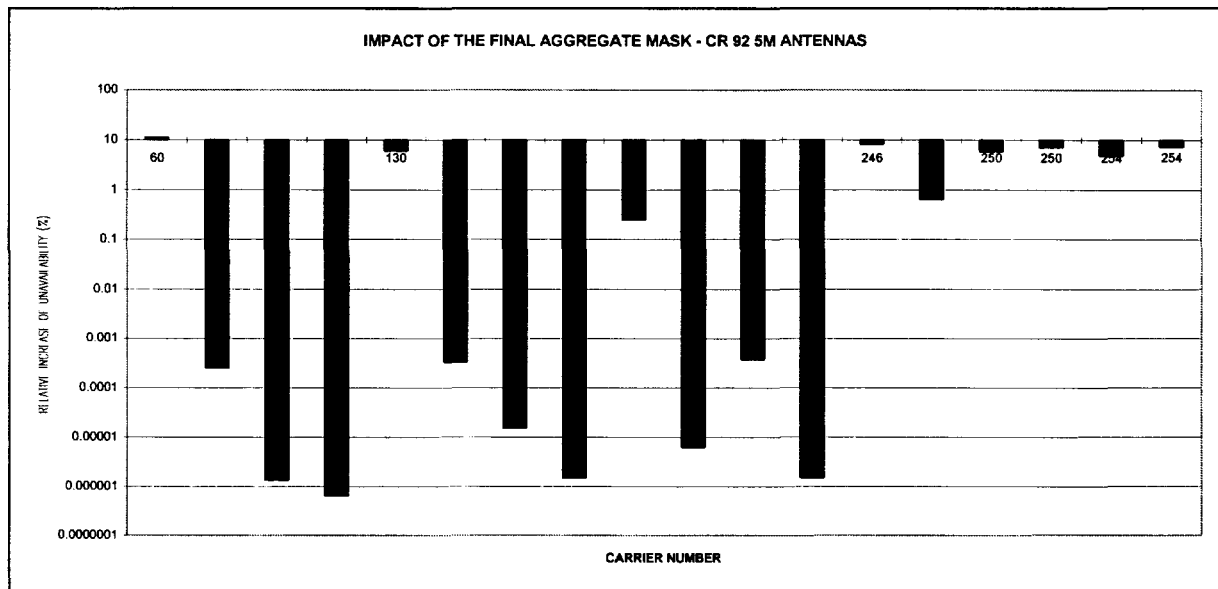
The CR-92 database, as of the close of the JTG Long Beach meeting, contains 16 carriers for 5 meter diameter antennas. The specified availability for these carriers ranges from 99% to 99.97%.

Carrier #8 was submitted by Intelsat at the JTG meeting in Toulouse. Intelsat claimed that its links were not optimized correctly and proposed modified links to take into account its concerns. Carrier #8 was replaced by Intelsat at the Long Beach meeting by carrier #246, which was used in this study.

3.5.2 Application of Procedure D to the sample of sensitive carriers

Procedure D was applied in a trial and error process, adjusting both the EPFD levels and the associated time percentages. For the carriers not meeting their initial performance objective, a 10% increase of the calculated unavailability has been taken into account.

The following graph presents the impact on the CR-92 5 m carriers of the aggregate mask :

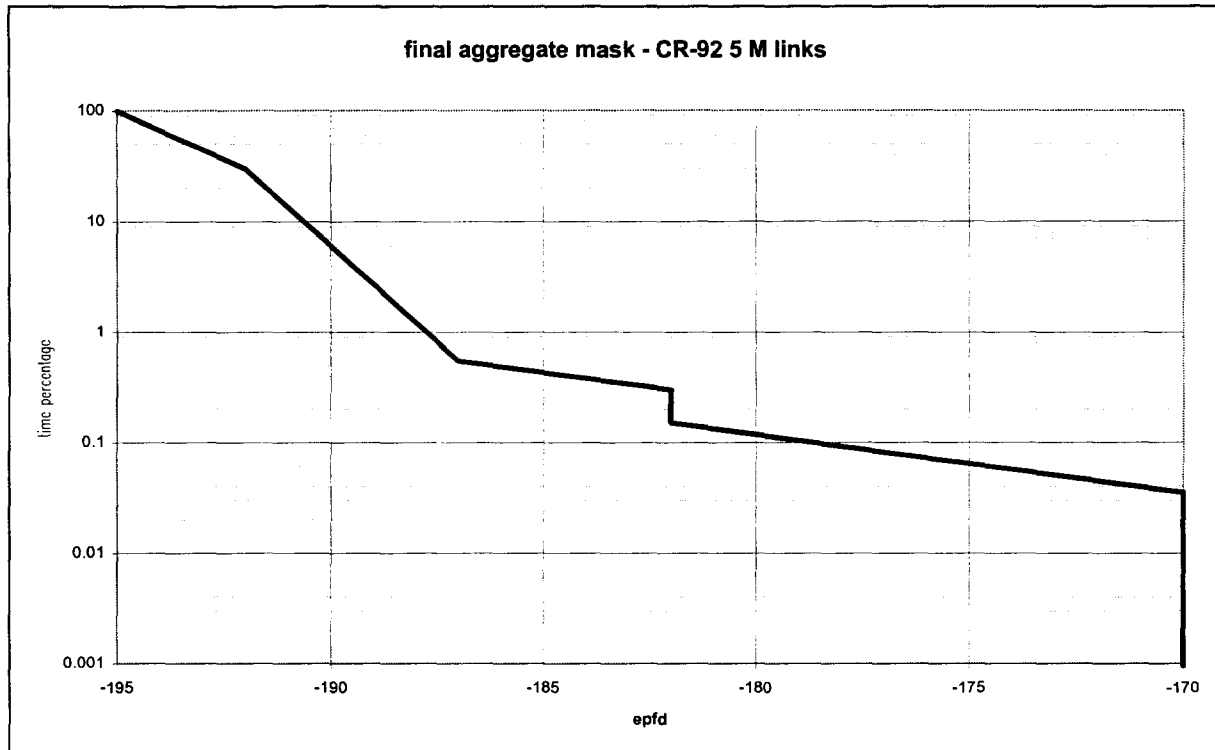


With the proposed mask, all the carriers meet recommends 3.1 of Recommendation S.1323 except one. Carrier #60 has a relative increase in availability of 11.16%, but still meets its objectives.

The percentage of links protected with respect to Rec. S.1323 is 94.12%. The percentage of links that meet their performance objectives without NGSOs and still meet their performance objectives with the NGSO aggregate interference is 100%. This means that with the proposed aggregate mask, NQ CR-92 carrier will suffer from a degradation of the objective availability due to the NGSO.

3.5.3 Final aggregate and single entry EPFD mask for 5 m antennas

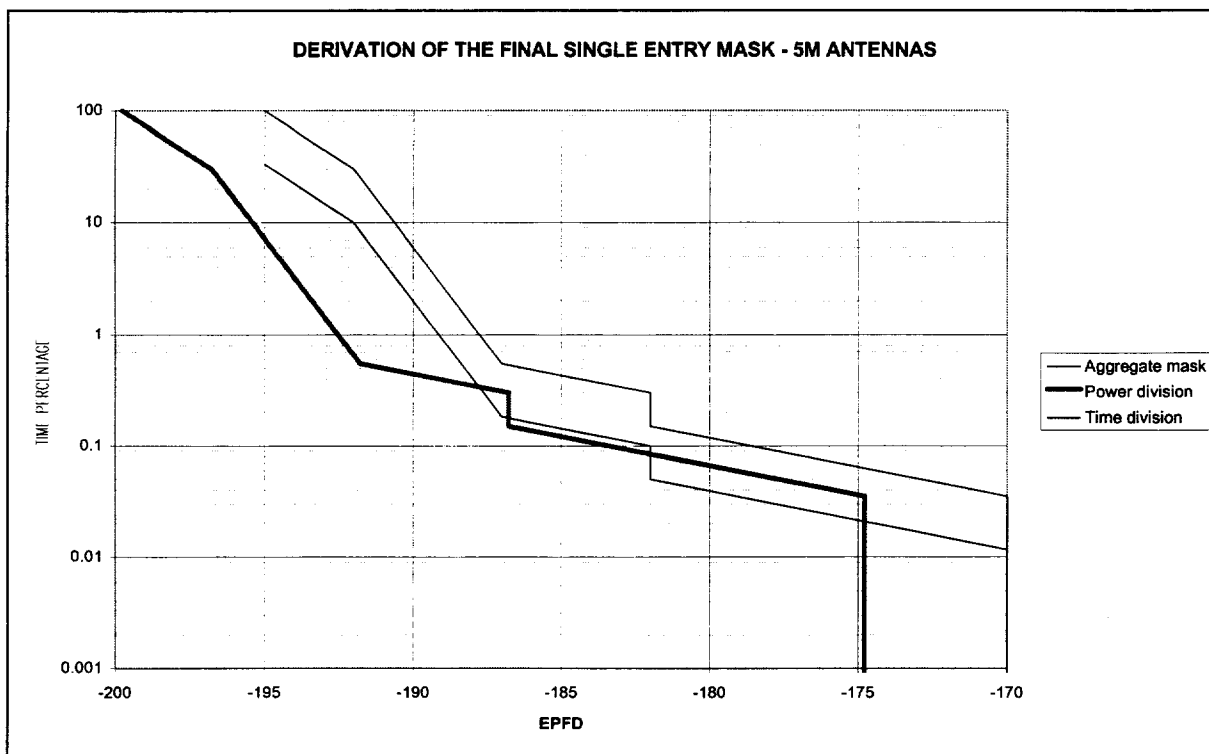
The following graph provides the aggregate EPFD mask verifying :



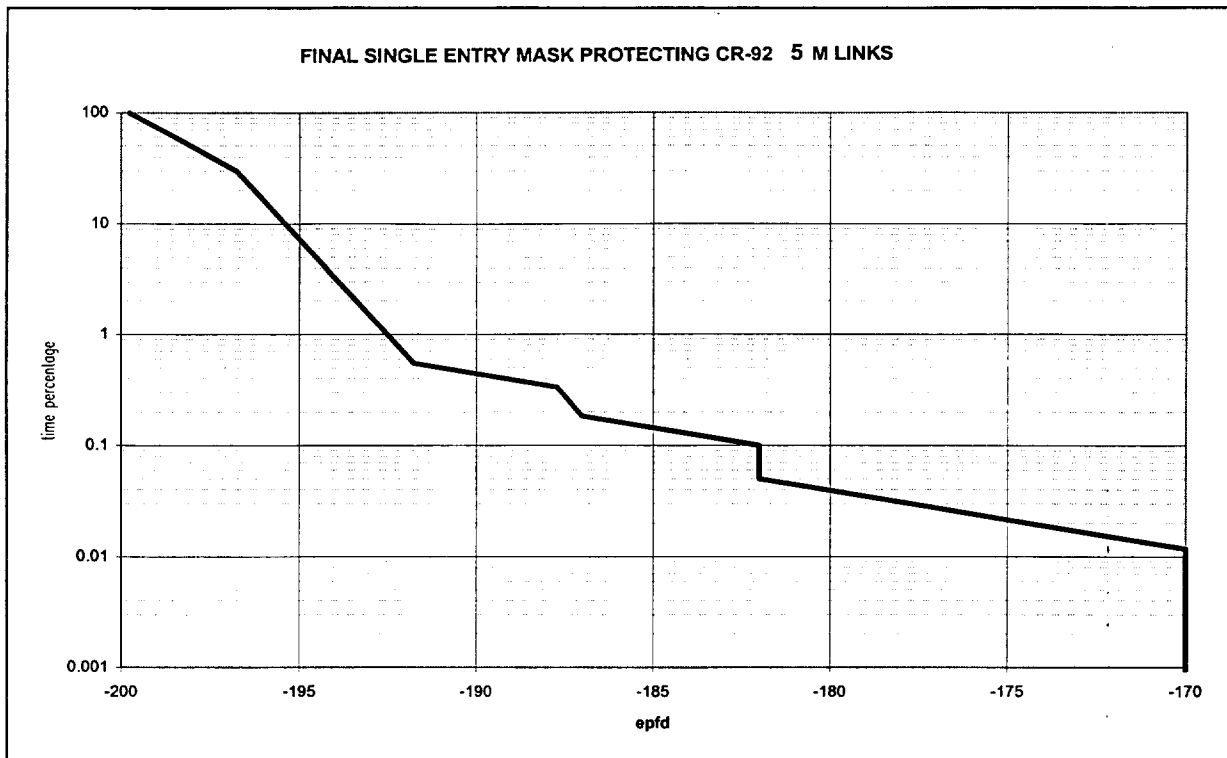
The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (Dbw/4kHz/m²)	Percentage of time the level can be exceeded (%)
-195	100
-192	30
-187	0.55
-182	0.3
-182	0.15
-170	0.035
-170	0

Applying the methodology described in Document JTG 4-9-11/253, the single entry mask is derived from the aggregate mask as shown in the following graph :



As can be seen in the above graph the “power division” and “time division” curves cross, and the envelope is taken to derive the single entry mask. Zone C was not used in this case. The final single entry mask is presented in the following graph.



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (Dbw/4kHz/m²)	Percentage of time the level can be exceeded (%)
-199.771213	100
-196.771213	30
-191.771213	0.55
-187.7	0.33
-187	0.183333333
-182	0.1
-182	0.05
-170	0.017
-170	0

4. Technical data

4.1 60 CM ANTENNAS- IMPACT OF THE FINAL AGGREGATE MASK

Carrier Name / Number	22	34	40	41	42	43	72	73	74	75
Combination step	0.005	0.005								
Rain model / step	ITU / 0.00004	ITU / 0.00004								
Required performances	#1	#1	#2	#2	#2	#2	#2	#2	#2	#2
total link C/(N+I) (dB)	8	4.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
availability (%)	99.6	99.7	99	99.7	99.9	99.97	99	99.7	99.9	99.97
Calculated performances	#1	#1	#2	#2	#2	#2	#2	#2	#2	#2
C/(N+I) (dB)	8	4.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
availability without ngso's (%)	99.532	99.954	99.332	99.985	99.986	99.986	99.303	99.982	99.984	99.985
availability with ngso's (%)	99.499	99.952	99.234	99.985	99.986	99.986	99.205	99.982	99.984	99.985
Relative unavailability variation	6.98	0.64	9.84	0.00	0.00	0.00	9.81	0.00	0.00	0.00

Carrier Name / Number	91	92	93	94	110	111	112	113	5	5B
Combination step									0.005	
Rain model / step									ITU / 0.00004	
Required performance s	#2	#2	#2	#2	#2	#2	#2	#2	#1	#2
Total link C/(N+I) (dB)	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	10.9	6.9
Availability (%)	99	99.7	99.9	99.97	99	99.7	99.9	99.97	99	99.9
Calculated performance s	#2	#2	#2	#2	#2	#2	#2	#2	#1	#2
C/(N+I) (dB)	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	10.9	6.9
Availability without ngso's (%)	99.151	99.698	99.821	99.956	99.152	99.691	99.876	99.951	99.696	99.933
Availability with ngso's (%)	99.002	99.674	99.811	99.955	99.004	99.667	99.872	99.950	99.669	99.932
Relative unavailability variation	14.94	7.94	5.10	1.30	14.73	7.58	3.68	1.37	2.63	0.53

Carrier Name / Number	239	239B	213	267	268
Combination step				0.005	0.005
Rain model / step				ITU / 0.00004	ITU / 0.00004
Required performance s	#2	#3	#2	#1	#1
Total link C/(N+I) (dB)	5.5	4.8	7	3.853376574	3.853376574
Availability (%)	99	99.6	99	99.5	99.5
Calculated performance s	#2	#3	#2	#1	#1
C/(N+I) (dB)	5.5	4.8	7	3.853376574	3.853376574
Availability without ngso's (%)	99.216	99.404	99.303	0.000	0.000
Availability with ngso's (%)	99.207	99.398	99.259	0.000	0.000
Relative unavailability variation	0.98	0.95	4.39	0.00	0.00

4.2 3 M ANTENNAS - IMPACT OF THE FINAL AGGREGATE MASK

Carrier Name / Number	35	56	57	58	59	126	127	128	129	158
Combination step	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Rain model / step	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004
Required performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
Total link C/(N+I) (dB)	4.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5
Availability (%)	99.7	99	99.7	99.9	99.97	99	99.7	99.9	99.97	99
Calculated performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
C/(N+I) (dB)	4.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5
Availability without ngso's (%)	99.972	99.316	99.962	99.970	99.976	99.207	99.942	99.955	99.969	99.182
Availability with ngso's (%)	99.887	99.153	99.962	99.970	99.976	99.110	99.942	99.955	99.969	99.000
Objectives	28.39	16.32	0.00	0.00	0.00	9.74	0.00	0.19	0.00	18.20

Carrier Name / Number	159	160	161	190	191	192	193	26	247	
Combination step	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Rain model / step	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	
Required performance s	#1	#1	#1	#1	#1	#1	#1	#1	#1	#2
Total link C/(N+I) (dB)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	8.2	11.1	9
Availability (%)	99.7	99.9	99.97	99	99.7	99.9	99.97	99.9	99.36	99.96
Calculated performance s	#1	#1	#1	#1	#1	#1	#1	#1	#1	#2
C/(N+I) (dB)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	8.2	11.1	9
Availability without ngso's (%)	99.957	99.965	99.972	99.105	99.928	99.948	99.965	99.802	99.867	99.944
Availability with ngso's (%)	99.957	99.965	99.972	99.001	99.928	99.948	99.965	99.799	99.864	99.943
Objectives	0.00	0.00	0.00	10.04	0.00	0.00	0.00	1.69	0.47	0.68

Carrier Name / Number	251		255	
Combination step	0.01		0.01	
Rain model / step	ITU / 0.00004		ITU / 0.00004	
Required performance s	#1	#2	#1	#2
Total link C/(N+I) (dB)	7.9	5	7.7	5
Availability (%)	99	99.6	99	99.6
Calculated performance s	#1	#2	#1	#2
C/(N+I) (dB)	7.9	5	7.7	5
Availability without ngso's (%)	98.001	99.513	97.918	99.461
Availability with ngso's (%)	97.888	99.509	97.815	99.457
Objectives	5.69	0.79	4.97	0.72

4.3 10 M ANTENNAS - IMPACT OF THE FINAL AGGREGATE MASK

Carrier Name / Number	33	64B	65B	66B	67B	134B	135B	136B	137B	166B	167B	168B	169B	198B
Required performances	#1	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2
Total link C/(N+I) (dB)	6.7	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5	6.5	6.5	6.5	6.5
Availability (%)	99.8	99	99.7	99.9	99.97	99	99.7	99.9	99.97	99	99.7	99.9	99.97	99
Calculated performances	#1	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2	#2
C/(N+I) (dB)	6.7	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5	6.5	6.5	6.5	6.5
Availability without ngso's (%)	99.97	99.37	99.93	99.95	99.97	99.17	99.91	99.94	99.96	99.10	99.92	99.94	99.96	99.08
Availability with ngso's (%)	99.91	99.31	99.93	99.95	99.97	99.14	99.91	99.94	99.96	99.03	99.92	99.94	99.96	99.04
Compared to objectives (%)	27.90	6.55	0.00	0.00	0.00	3.78	0.00	0.00	0.00	7.12	0.00	0.00	0.00	3.78
Relative unavailability variation	27.90	6.55	0.00	0.00	0.00	3.78	0.00	0.00	0.00	7.12	0.00	0.00	0.00	3.78

Carrier Name / Number	199B	200B	201B	200B	201B	236	244B	244C	248B	248B	252B	252C	46	47
Required performances	#2	#2	#2	#2	#2	#1	#2	#3	#2	#3	#2	#3	#1	#1
Total link C/(N+I) (dB)	6.5	6.5	6.5	6.5	6.5	6.7	11.1	9	7.5	5	7.5	5	9.4	16.9
Availability (%)	99.7	99.9	99.97	99.9	99.97	99.96	99.36	99.96	99	99.6	99	99.6	99.99	99.99
Calculated performances	#2	#2	#2	#2	#2	#1	#2	#3	#2	#3	#2	#3	#1	#1
C/(N+I) (dB)	6.5	6.5	6.5	6.5	6.5	6.7	11.1	9	7.5	5	7.5	5	9.4	16.9
Availability without ngso's (%)	99.90	99.94	99.96	99.94	99.96	99.94	99.84	99.93	97.33	99.16	97.25	99.16	99.20	98.57
Availability with ngso's (%)	99.90	99.94	99.96	99.94	99.96	99.90	99.78	99.88	97.25	99.12	97.16	99.10	99.16	98.51
Compared to objectives (%)	0.00	0.00	0.00	0.00	0.00	101.99	9.47	113.50	7.96	11.62	9.02	13.60	354.02	575.66
Relative unavailability variation	0.00	0.00	0.00	0.00	0.00	71.87	9.47	62.66	2.99	5.56	3.28	6.44	4.40	4.03

5 M ANTENNAS - IMPACT OF THE FINAL AGGREGATE MASK

Carrier Name / Number	60	61	62	63	130	131	132	133	162	163	164	165
Required performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
total link C/(N+I) (dB)	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5	6.5	6.5	6.5
availability (%)	99	99.7	99.9	99.97	99	99.7	99.9	99.97	99	99.7	99.9	99.97
Calculated performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
C/(N+I) (dB)	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	6.5	6.5	6.5	6.5
availability without ngso's (%)	99.323	99.950	99.961	99.972	99.308	99.926	99.946	99.966	99.696	99.941	99.956	99.968
availability with ngso's (%)	99.212	99.950	99.961	99.972	99.248	99.926	99.946	99.966	99.694	99.941	99.956	99.968
Relative unavailability variation	11.161	0.000	0.000	0.000	6.059	0.000	0.000	0.000	0.247	0.000	0.000	0.000

Carrier Name / Number	246	246	250	250	254	254
Required performances	#2	#3	#2	#3	#2	#3
total link C/(N+I) (dB)	11.1	9	7.5	5	7.5	5
availability (%)	99.36	99.96	99	99.6	99	99.6
Calculated performances	#2	#3	#2	#3	#2	#3
C/(N+I) (dB)	11.1	9	7.5	5	7.5	5
availability without ngso's (%)	99.842	99.930	97.669	99.341	97.755	99.377
availability with ngso's (%)	99.789	99.929	97.532	99.295	97.649	99.332
Relative unavailability variation	8.212	0.631	5.847	7.073	4.722	7.248

4.4 1.2 M ANTENNAS – IMPACT OF THE FINAL AGGREGATE MASK

Carrier Name / Number	14	17	44	45	46	47	76	77	78	79
Combination step	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rain model / step	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004
Required performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
total link C/(N+I) (dB)	8	7.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
availability (%)	99.95	99.94	99	99.7	99.9	99.97	99	99.7	99.9	99.97
Calculated performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
C/(N+I) (dB)	8	7.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
availability without ngso's (%)	99.955	99.929	99.387	99.984	99.985	99.986	99.387	99.978	99.982	99.984
availability with ngso's (%)	99.955	99.918	99.338	99.984	99.985	99.986	99.342	99.978	99.982	99.984
OBJECTIVES	0.886	15.445	4.926	0.000	0.000	0.000	4.525	0.000	0.001	0.000

Carrier Name / Number	95	96	97	98	114	115
Combination step	0.05	0.05	0.05	0.05	0.05	0.05
Rain model / step	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004
Required performances	#1	#1	#1	#1	#1	#1
total link C/(N+I) (dB)	6.1	6.1	6.1	6.1	6.1	6.1
availability (%)	99	99.7	99.9	99.97	99	99.7
Calculated performances	#1	#1	#1	#1	#1	#1
C/(N+I) (dB)	6.1	6.1	6.1	6.1	6.1	6.1
availability without ngso's (%)	99.169	99.683	99.872	99.953	99.156	99.674
availability with ngso's (%)	99.063	99.663	99.868	99.952	99.060	99.655
OBJECTIVES	10.644	6.351	3.104	2.046	9.621	5.842

Carrier Name / Number	116	117	146	147	148	149	178	179	180	181
Combination step	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rain model / step	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004	ITU / 0.00004
Required performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
total link C/(N+I) (dB)	6.1	6.1	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
availability (%)	99.9	99.97	99	99.7	99.9	99.97	99	99.7	99.9	99.97
Calculated performances	#1	#1	#1	#1	#1	#1	#1	#1	#1	#1
C/(N+I) (dB)	6.1	6.1	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
availability without ngso's (%)	99.867	99.949	99.231	99.983	99.984	99.985	99.333	99.977	99.980	99.983
availability with ngso's (%)	99.864	99.948	99.142	99.983	99.984	99.985	99.288	99.977	99.980	99.983
OBJECTIVES	1.991	0.658	8.884	0.000	0.000	0.000	4.471	0.000	0.001	0.001

Carrier Name / Number	238		241		243		202B	203B	204B	205B
Combination step	0.05		0.05		0.05					
Rain model / step	ITU / 0.00004		ITU / 0.00004		ITU / 0.00004					
Required performances	#1	#2	#1	#2	#1	#2	#2	#2	#2	#2
total link C/(N+I) (dB)	8.3	7.6	8.2	5	7.9	5	5.8	5.8	5.8	5.8
availability (%)	99	99.6	99	99.6	99	99.6	99.96	99.96	99.6	99.6
Calculated performances	#1	#2	#1	#2	#1	#2	#2	#2	#2	#2
C/(N+I) (dB)	8.3	7.6	8.2	5	7.9	5	5.8	5.8	5.8	5.8
availability without ngso's (%)	99.159	99.355	97.318	99.462	97.443	99.423	99.950	99.907	99.440	99.408
availability with ngso's (%)	99.157	99.354	97.148	99.452	97.299	99.413	99.949	99.907	99.426	99.387
OBJECTIVES	0.152	0.156	6.348	1.766	5.657	1.730	1.761	0.574	2.514	3.537

Carrier Name / Number	206B	207B	208B	209B	210B	211B	212B
Combination step							
Rain model / step							
Required performances	#2	#2	#2	#2	#2	#2	#2
total link C/(N+I) (dB)	5.8	5.8	5.8	5.8	5.8	5.8	5.8
availability (%)	99.6	99.96	99.96	99.96	99.96	99.96	99.96
Calculated performances	#2	#2	#2	#2	#2	#2	#2
C/(N+I) (dB)	5.8	5.8	5.8	5.8	5.8	5.8	5.8
availability without ngso's (%)	99.465	99.941	99.955	99.931	99.934	99.933	99.928
availability with ngso's (%)	99.452	99.940	99.954	99.930	99.934	99.933	99.928
OBJECTIVES	2.472	1.601	1.433	1.360	0.021	0.165	0.014

B

APPENDIX B

DERIVATION OF EPFD LIMITS FOR PROTECTION OF GSO BSS SYSTEMS

1. Introduction

As discussed in Section III, JWP 10-11S and JTG 4-9-11 are conducting the studies necessary to assess the adequacy of the WRC-97 provisional limits. This document uses the results of those studies to date, including the Preliminary Draft New Recommendation developed by JWP 10-11S (Document 4-9-11/217), in order to derive single entry EPFD masks. The methodology is very similar to the one developed by WP 4A and contained in Recommendation S.1323 (see Annex A).

The methodology has been applied to the carriers provided by the administrations in response to Circular Letter CR-92. The resulting proposed masks will ensure the protection of GSO BSS and associated feeder links in compliance with recommends 1.1 of the JWP 10-11S P.D.N.R., and more adequately model the interference generated by NGSO FSS systems than the discrete WRC-97 limits.

2. Derivation of the EPFD masks

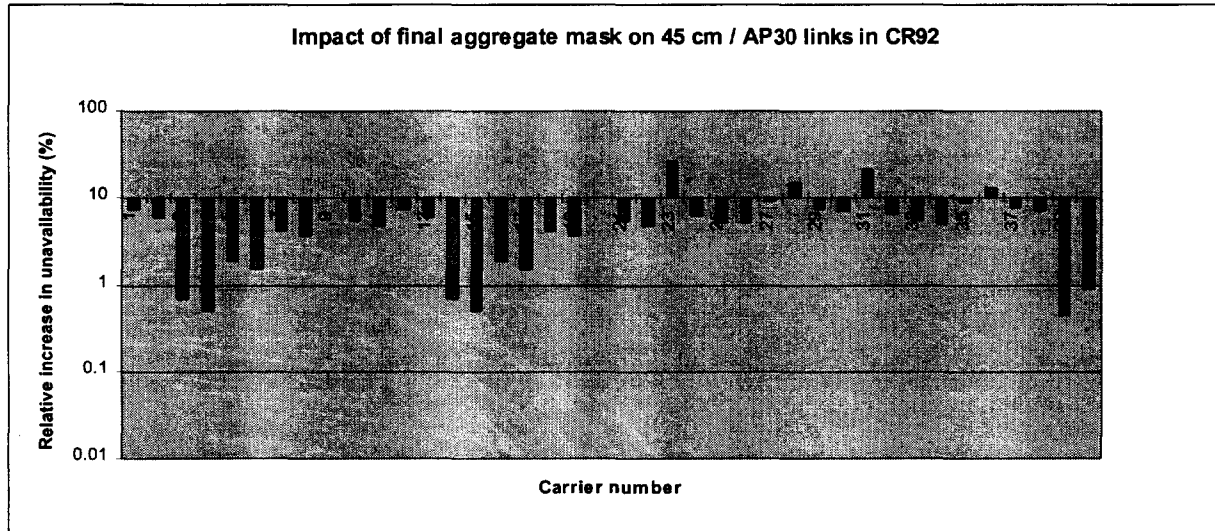
2.1 Derivation of EPFD mask for 45 cm antennas

2.1.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 43 carriers for 45 cm diameter antennas operating in Region 2. Three of these carriers (US-GSO 4, US-GSO 5(a), and US-GSO 5(b)) could not be taken into account because key information is missing (e.g., receive antenna gain and/or earth station locations). All of the remaining carriers have been taken into account when deriving the single entry EPFD mask.

2.1.2 Application of the methodology to the sample of sensitive carriers

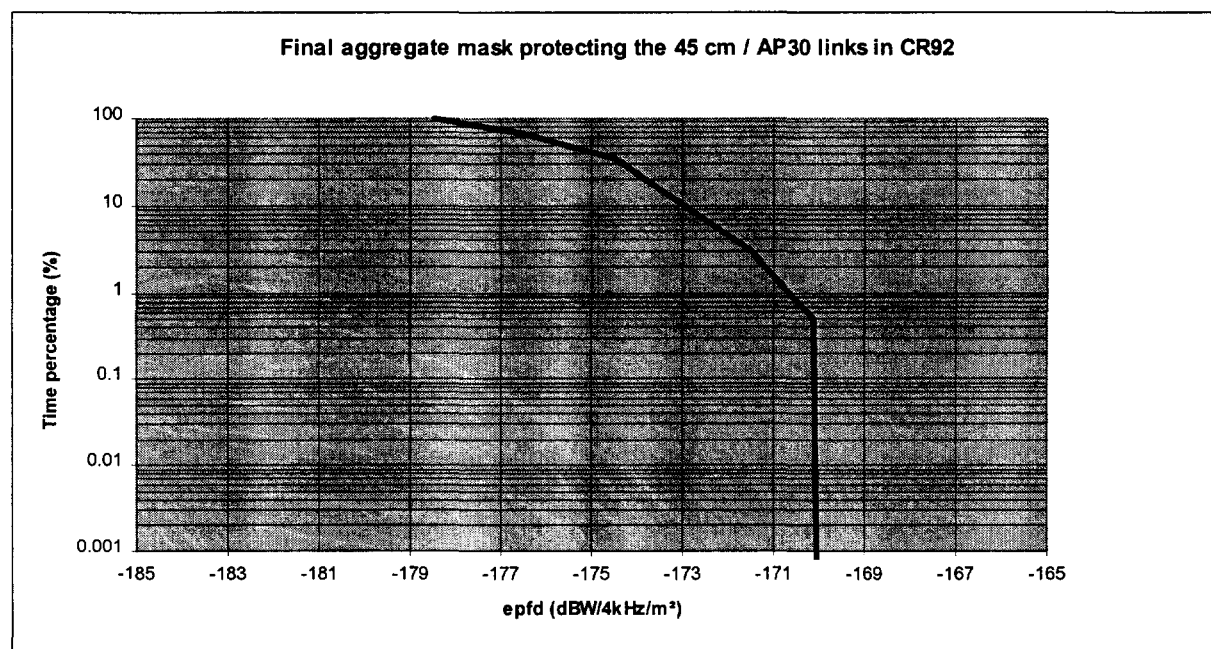
The following graph presents the impact on the CR-92 45 cm carriers operating in Region 2 of the derived aggregate mask :



With the proposed mask, all 40 carriers meet recommends 1.1 of the P.D.N.R. except four. The common characteristic of these four links is their limited availability (between 99.5% and 99.7%). The percentage of links protected with respect to recommends 1.1 of the PDNR is 90%. The percentage of links protected with respect to recommends 1.2 of the PDNR (no freeze frame) is 100%. The CR-92 links are considered to be the most sensitive links submitted by administrations.

2.1.3 Final aggregate and single entry EPFD mask for 45 cm antennas

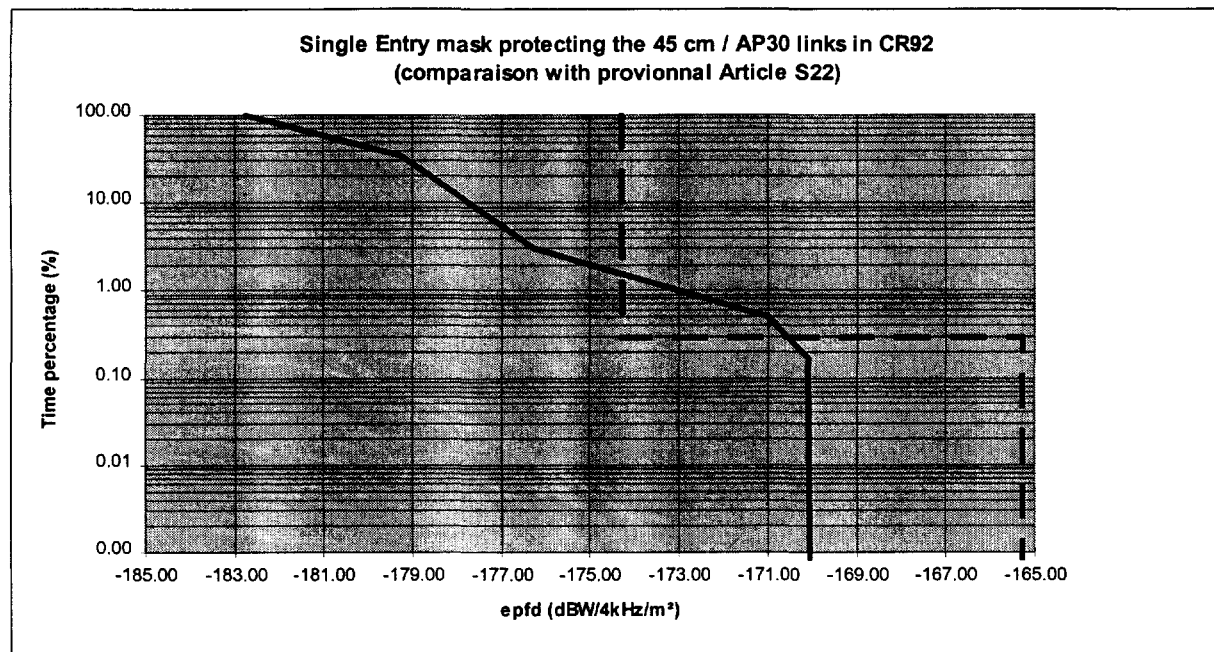
The following graph provides the aggregate EPFD mask :



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-178.5	100
-176.5	67
-174.5	34
-171.5	3
-171	1.5
-170.1	0.5
-170	0.0

The following graph provides the single entry EPFD mask, which can be found when applying the methodology described in Appendix A. It also provides a comparison with the provisional EPFD limits currently contained in Article S22 of the Radio Regulations:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m ²)	Percentage of time the level can be exceeded (%)
-182.77	100.00
-179.27	34.00
-176.27	3.00
-171.00	0.50
-170.10	0.17
-170.00	0.00

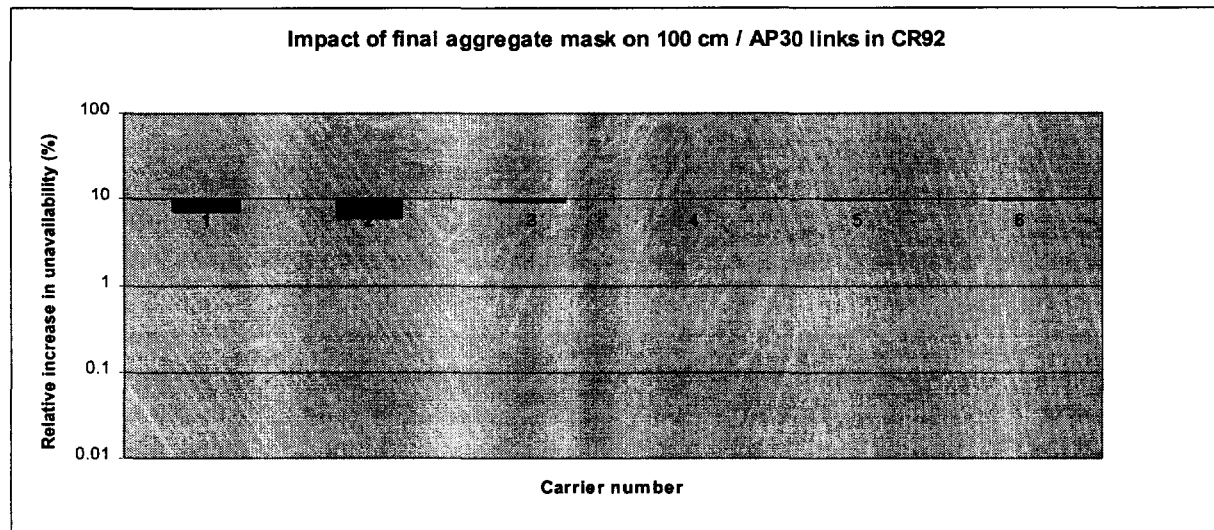
2.2 Derivation of EPFD mask for 100 cm antennas

2.2.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 7 carriers for 100 cm diameter antennas operating in Region 2. The "100 cm" category includes diameters between 90 cm and 100 cm (10% tolerance). The mask developed for 100 cm antennas will be tighter and offer more protection than one developed for 90 cm antennas. One carrier (Ref. RARC-83 Region 2) could not be taken into account because key information is missing (e.g., earth station locations). All of the remaining six carriers have been taken into account when deriving the single entry EPFD mask.

2.2.2 Application of the methodology to the sample of sensitive carriers

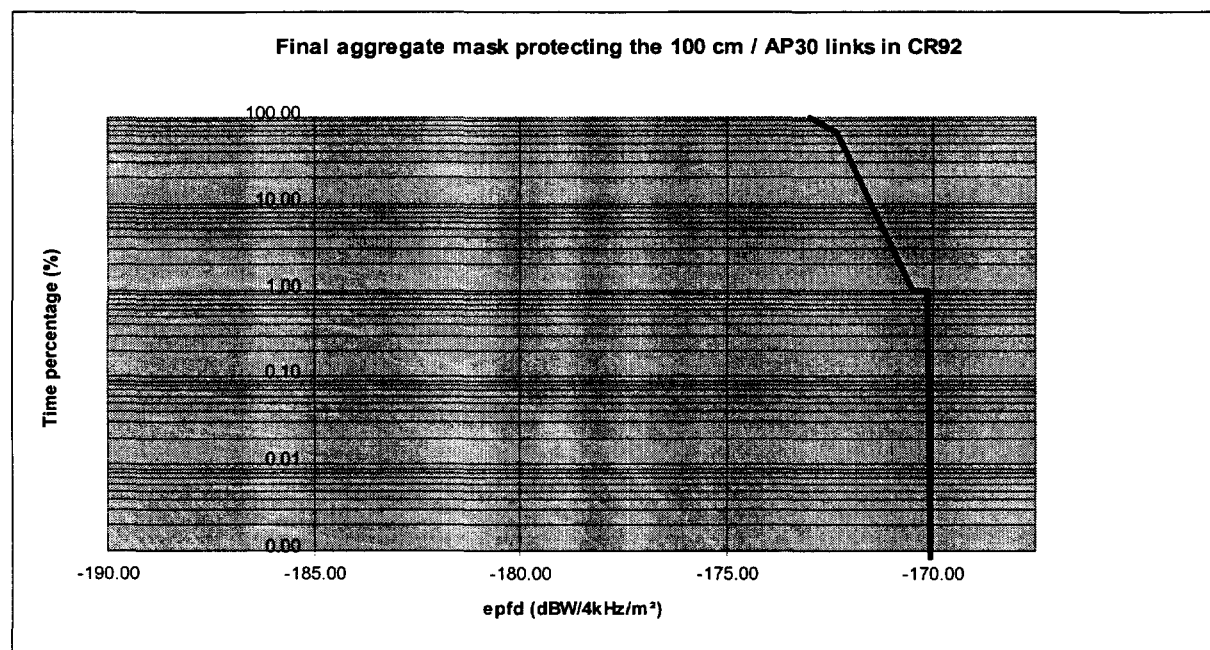
The following graph presents the impact on the CR-92 100 cm carriers operating in Region 2 of the derived aggregate mask :



With the proposed mask, all six carriers meet the recommends 1.1 of the P.D.N.R. The percentage of links protected with respect to recommends 1.1 of the PDNR is 100%. The CR-92 links are considered to be the most sensitive links submitted by administrations. (For carriers 4 through 6, the relative unavailability reduction is just below 10% and therefore does not appear on the graph.) The percentage of links protected with respect to recommends 1.2 of the PDNR is 100%.

2.2.3 Final aggregate and single entry EPFD mask for 100 cm antennas

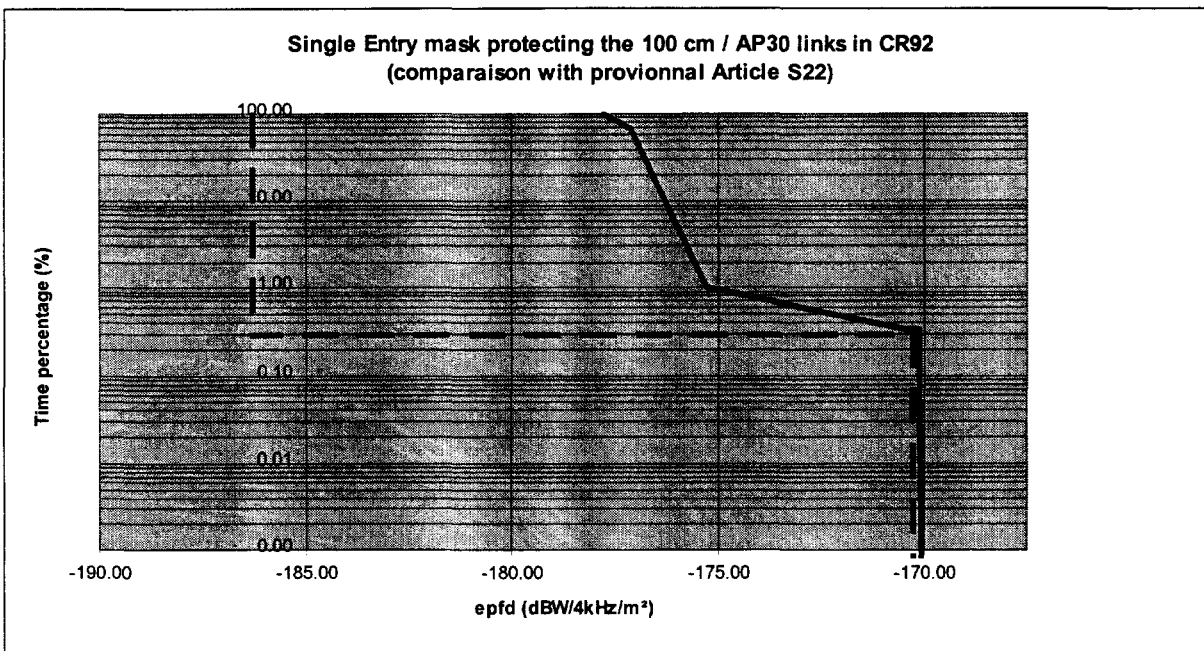
The following graph provides the aggregate EPFD mask :



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-173	100.00
-172.33	67.00
-170.50	1.00
-170.10	1.00
-170.00	0.00

The following graph provides the single entry EPFD mask, which can be found by applying the methodology described in Appendix A. It also provides a comparison with the provisional EPFD limits currently contained in Article S22 of the Radio Regulations:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m ²)	Percentage of time the level can be exceeded (%)
-177.77	100.00
-177.10	67.00
-175.27	1.00
-170.50	0.33
-170.10	0.33
-170.00	0.00

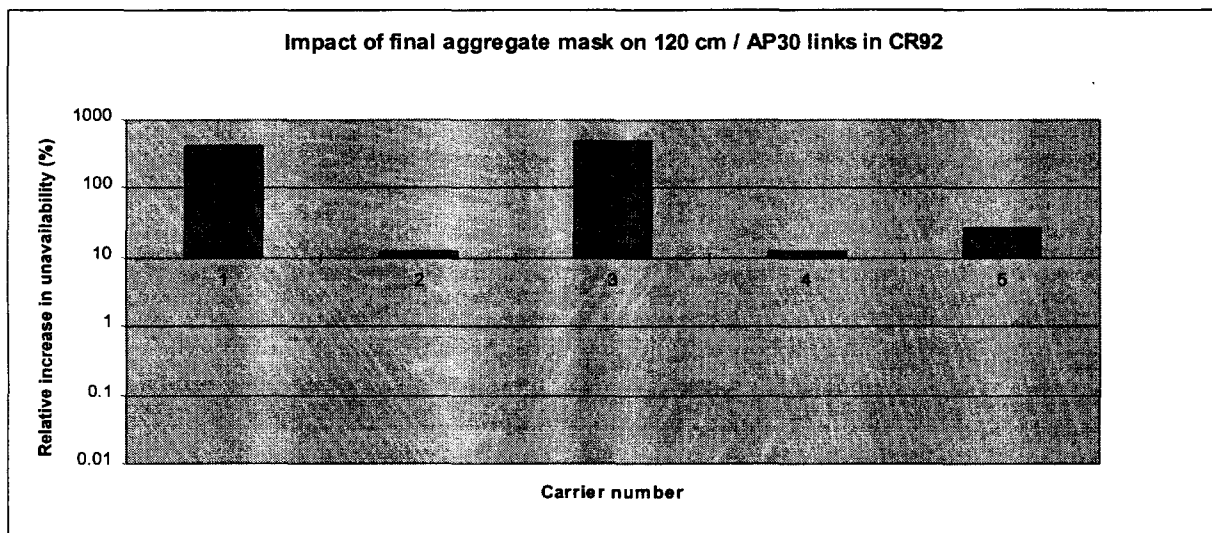
2.3 Derivation of EPFD mask for 120 cm antennas

2.3.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 5 carriers for 120 cm diameter antennas operating in Region 2. All of these carriers have been taken into account when deriving the single entry EPFD mask.

2.3.2 Application of the methodology to the sample of sensitive carriers

The following graph presents the impact on the CR-92 120 cm carriers operating in Region 2 of the derived aggregate mask :

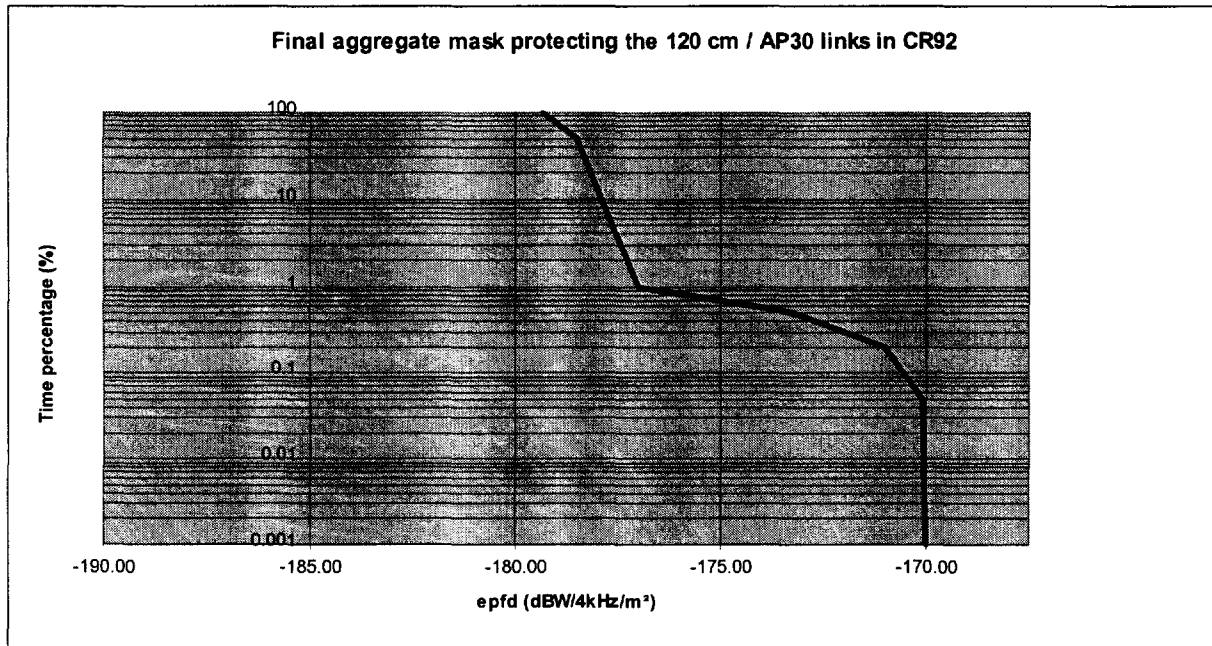


For all of the 120 cm carriers:

- All locations are above 70° N latitude. In 4 cases, the elevation angle is lower than 10°.
- The results are extremely sensitive to EIRP variation (e.g., a 1 dB increase in EIRP changes the percentage by a factor of 10).
- The EIRP of the satellite is specified around 40 dBW. It is likely that this figure corresponds to a piling up of worst cases (satellite attitude, spacecraft antenna pointing accuracy, thermo-mechanical effect on spacecraft antenna, etc.), and therefore most of the time, the actual EIRP will be a few dB's higher.

2.3.3 Final aggregate and single entry EPFD mask for 120 cm antennas

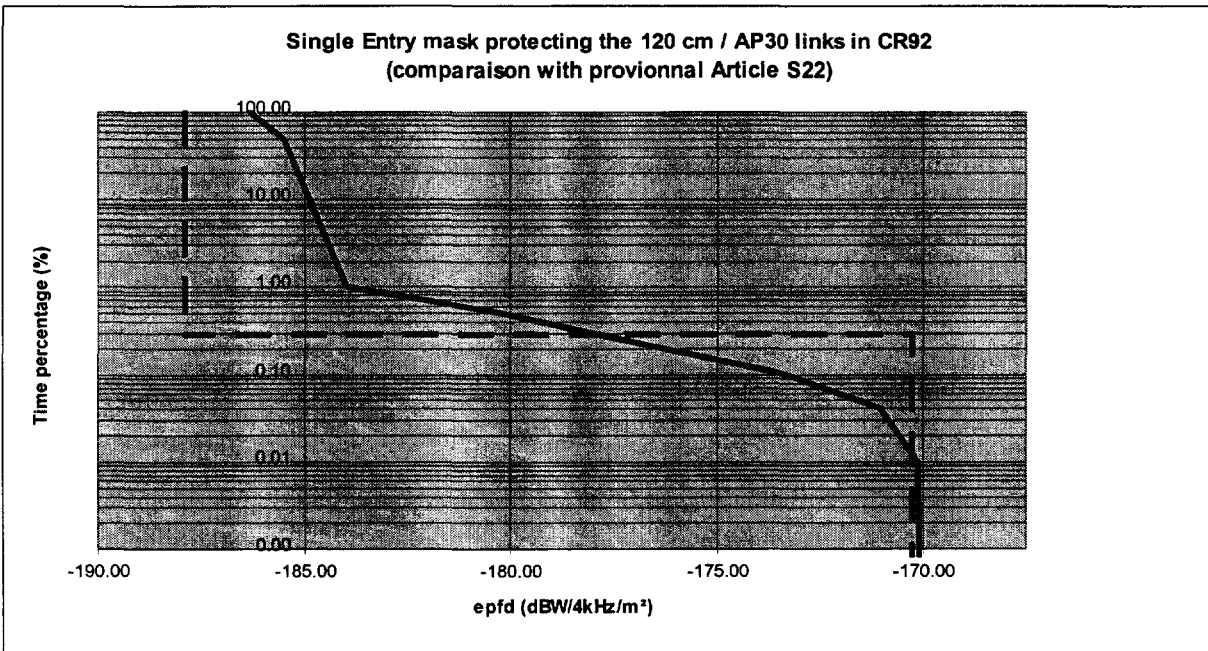
The following graph provides the aggregate EPFD mask:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-179.33	100.00
-178.5	50.00
-177	1.00
-173.25	0.50
-171	0.20
-170.1	0.05
-170	0.00

The following graph provides the single entry EPFD mask, which can be found by applying the methodology described in Appendix A. It also provides a comparison with the provisional EPFD limits currently contained in Article S22 of the Radio Regulations:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-186.33	100.00
-185.49	50.00
-184.00	1.00
-180.25	0.50
-173.25	0.10
-171	0.04
-170.1	0.01
-170	0.00

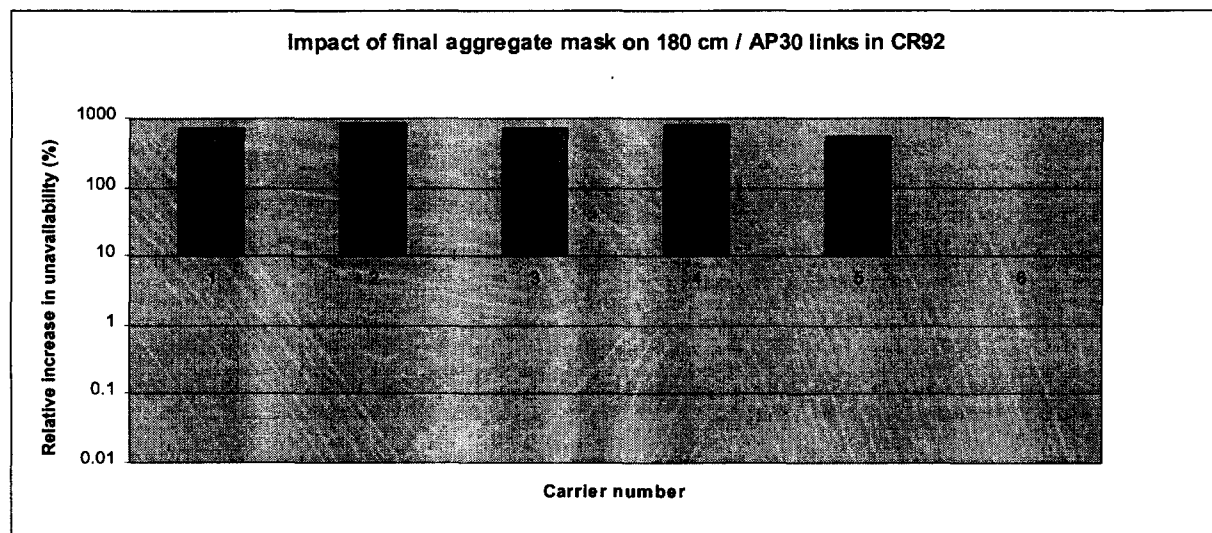
2.4 Derivation of EPFD mask for 180 cm antennas

2.4.1 Carriers in the CR-92 database

The CR-92 database, as of the close of the JTG Long Beach meeting, contains 7 carriers for 180 cm diameter antennas. Two carriers (US-GSO 5(d) and US-GSO 5(e)) could not be taken into account because key information is missing (e.g., earth station locations).

2.4.2 Application of the methodology to the sample of sensitive carriers

The following graph presents the impact on the CR-92 180 cm carriers operating in Region 2 of the derived aggregate mask :



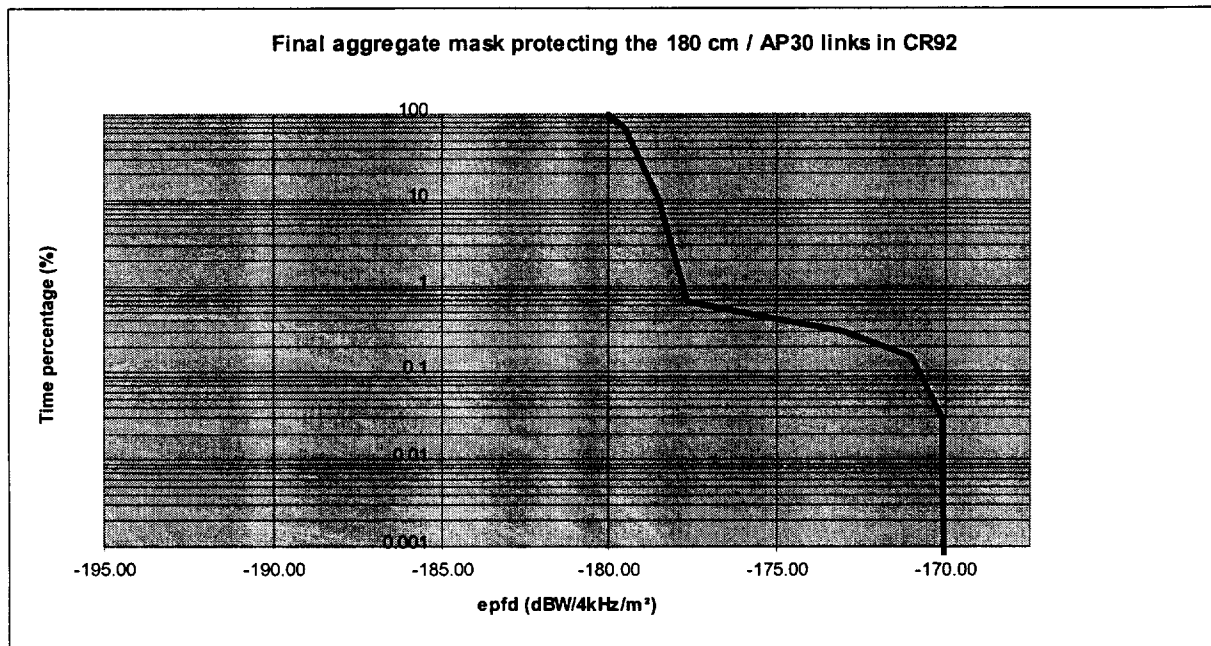
The results are explained by the fact that recommends 1.2 of the PDNR is not met for any of the 5 carriers. Moreover three of them have a very low clear-sky margin and can handle no more than 0.5 dB of rain attenuation.

All these carriers are characterized by a very low EIRP (around 35 dBW) and are located in high latitude areas. It is very likely that these parameters represent a very worst-case situation (multiple worst-case assumptions), and that the EIRP will be in most cases higher by a few dB's. As for the 120 cm, antennas, any improvement of the EIRP may drastically improve the results.

As discussed in Section III.B, this mask (as well as the others) will be revisited after administrations provide additional links prior to the March 15, 1999 deadline established by the JTG.

2.4.3 Final aggregate and single entry EPFD mask for 180 cm antennas

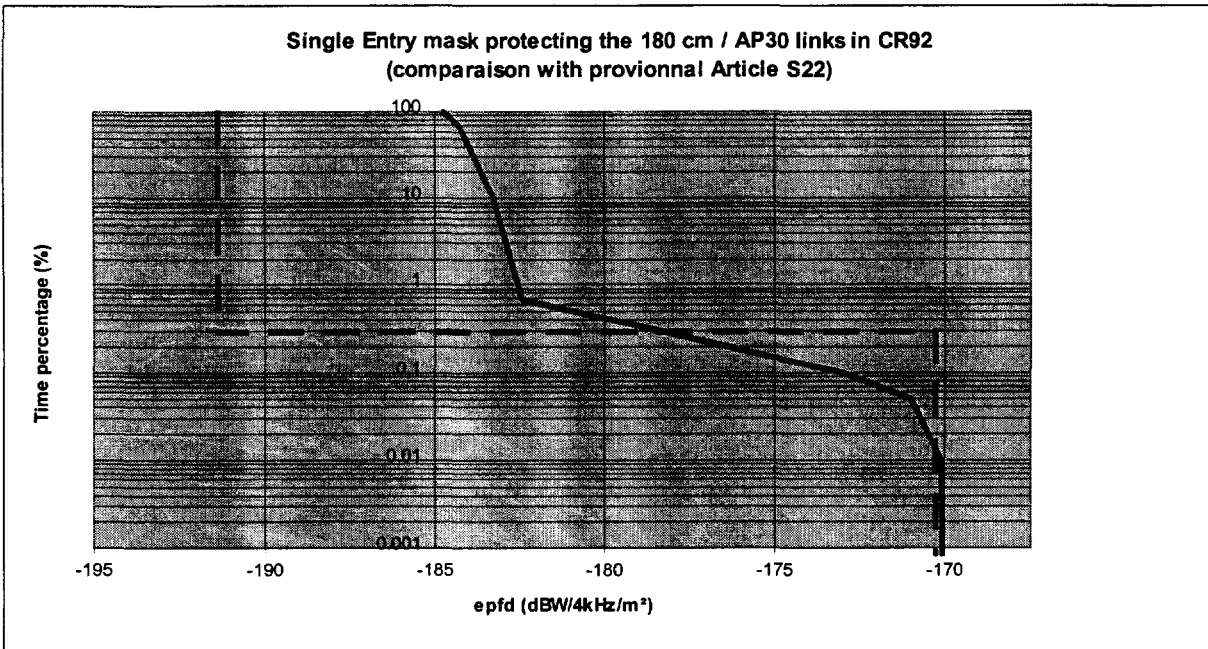
The following graph provides the aggregate EPFD mask:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-180.00	100
-179.5	67
-178.5	10
-177.66	0.67
-173.00	0.3
-171	0.15
-170.1	0.03
-170	0.00

The following graph provides the single entry EPFD mask, which can be found by applying the methodology described in Appendix A. It also provides a comparison with the provisional EPFD limits currently contained in Article S22 of the Radio Regulations:



The equation of the mask is given by the following points. Between the points a linear interpolation has been chosen.

EPFD (dBW/4kHz/m²)	Percentage of time the level can be exceeded (%)
-184.77	100
-184.27	67
-183.27	10
-182.43	0.67
-173	0.10
-171	0.05
-170.1	0.01
-170	0.00

3. Technical data

3.1 45 CM LINKS USED IN THE ANALYSIS

45 cm / AP30 links used from CR92 database

1	2	3	4	5	6	7	8	9	10
USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
US-GSO 1(a)	US-GSO 1(b)	US-GSO D1(a)	US-GSO D1(b)	US-GSO D2(a)	US-GSO D2(b)	US-GSO D3(a)	US-GSO D3(b)	US-GSO D4	US-GSO D6(a)

11	12	13	14	15	16	17	18	19	20
USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
US-GSO D6(b)	US-GSO D7(a)	US-GSO D7(b)	US-GSO D8(a)	US-GSO D8(b)	US-GSO D9(a)	US-GSO D9(b)	US-GSO D10(a)	US-GSO D10(b)	US-GSO D11

21	22	23	24	25	26	27	28	29	30
USA	USA	Canada	Canada	Canada	Canada	Canada	Canada	Canada	Canada
US-GSO D12(a)	US-GSO D12(b)	CAN-2	CAN-3	CAN-4	CAN-7	CAN-8	CAN-11	CAN-13	CAN-14

31	32	33	34	35	36	37	38	39	40
Canada	Canada	Canada	Canada	Canada	Canada	Canada	Canada	Japan	Japan
CAN-45	CAN-46	CAN-47	CAN-50	CAN-51	CAN-54	CAN-56	CAN-57	Analogue	Digital

3.2 100 CM LINKS USED IN THE ANALYSIS

100 cm / AP30 links used from CR92 database

1	2	3	4	5	6
USA	USA	Canada	Canada	Canada	Canada
US-GSO 2(a)	US-GSO 2(b)	CAN-12	CAN-15	CAN-55	CAN-58

3.3 120 CM LINKS USED IN THE ANALYSIS

120 cm / AP30 links used from CR92 database

1	2	3	4	5
Canada	Canada	Canada	Canada	USA
CAN-16	CAN-41	CAN-59	CAN-84	US-GS0 D13

3.4 180 CM LINKS USED IN THE ANALYSIS

180 cm / AP30 links used from CR92 database

1	2	3	4	5
Canada	Canada	Canada	Canada	USA
CAN-1	CAN-23	CAN-44	CAN-66	US-GS0 D14